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THE EFFECTS OF WATER BODIES ON AIR TEMPERATURE AND HUMIDITY DURING THE PERIOD PRECEDING THEIR FREEZING OR OPENING

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NOTICE

In the study and computation of the thermic and freezing behavior of bodies of water, one must usually use data observed by meteorological stations situated on land and on the shore. Yet the meteorological conditions above bodies of water differ from the conditions on land. For this reason the necessity arises of introducing corrections, in particular of the temperature and humidity of the air measured over land, ie, of calculating the influence of a body of water on these meteorological elements.

The question of the necessity of studying changes in the temperature and humidity of the air above the aquatic surface of lakes and rivers was raised as far back as by A. I. Voejkovyj [6, 7], who took notice of the importance of such investigations.

S. A. Sapožnikova [21] presented examples of significant differences in the temperature and humidity of the air over land and water. For instance, according to the data for the Caspian Sea and a number of lakes in Kazachstan, the differences even in the average monthly temperatures of the air amount to as much as 6 degrees in March, 3 degrees in November, and 3.5 degrees in December.

In the work of P. A. Voroncov [8], carried out in the conditions of a non-freezing, bounded expanse of water with a temperature from -10 to -28 degrees, it was shown that in the 30 minutes of the passage the air above the water warmed 2.5-3.0 degrees. The work was carried out with the use of an attached balloon, and certain data for various heights are presented in it.

A. Niberg and L. Ra[illegible] [28] indicate that for a temperature on the shore of a river of about -18 degrees, the increment in the temperature above the water at a total distance of 100 meters from the shore and at a height of 3 meters above it was 0.4 degrees; at a height of 1 cm it was 2.7 degrees; at a height of 0.5 cm it was 11.5 degrees.

In connection with the question about the study of evaporation from planned resevoirs in the State Hydrological Institute in 1939-40, the author carried out investigations relating to the study of the behavior of air above bodies of water. In the work [14], we examined the influence of large bodies of water on the magnitude of the deficit of the moisture content of the air by data from "continental," "litoral," "river," and "lake" meteorological stations using as a sample Lakes Ladoga and Onega, and employing materials from the Onega Expedition of the State Hydrological Institute as well. For the seasons which interest us here, the following average monthly data from these studies may be cited. In April, the deficit of moisture content on the lakes was from 55-75% smaller than the magnitude of the moisture content deficit on the mainland; in September 20%; and in October (at the time of freezing) 12%.

The data cited reveal that the temperature and humidity of the air change noticeably over bodies of water, and the study of this question should be alloted adequate attention. These data, however, are not detailed enough for complete calculations of the periods of freezing and thawing of future resevoirs. The changes

in humidity are not compared here with the factors causing them, such as the difference in the water-air temperatures or the deficit of moisture content. The latter is generally calculated according to the temperature of the air, and not according to the temperature of the influencing agent--the water. Furthermore, for the said calculations periodical measurements are needed rather than average monthly.

Let us note that in previous investigations of the evaporation from bodies of water, the questions specifically of the effect of bodies of water on the humidity were not accorded sufficient attention. Ignorance of this factor may be explained by the fact that the correction for the effect of the body of water was assumed, evidently, to be so small, that its study did not deserve attention.

The first investigations of the influence of bodies of water were carried out by R. Marqvardt [27], and also by V. Peppler [29], on the data from observations of the temperature and humidity of the air over Lake Constance, gathered on small steamboats cruising in various directions out of a Zeppelin base in Friedrichshafen. Marqvardt examined periodical data for various durations of the movement of air from the shore. Peppler used the data for various periods of time.

Mention should also be made of the monograph of A. P. Braslavskij and Z. A. Vikulina [5], which gave the semi-empirical formulas for determining the temperature and humidity over a body of water

$$t_{200,x} = t'_{200} + (t_{np} - t'_{200})\, M_t$$

and

$$e_{200,x} = e'_{200} + (t_{np} - t'_{200})\, M_e$$

where $t_{200,x}$ and $e_{200,x}$ are the temperature and humidity of the air sought; t'_{200} and e'_{200} are the temperature and humidity on the shore; and t_{np} and e_{np} are the maximum values of the temperature and humidity at a height of 200 cm with an unlimited continuance of a stream of air above the water. The parameters t_{np}, e_{np}, M_t, and M_e depend on a number of factors: the temperature of the water, the velocity of the wind, the gradient and coefficient of the turbulent exchange.

The calculation was carried out for average monthly (including multi-year) magnitudes with positive temperatures of the air. The authors obtained good agreement between the calculated and observed values.

Questions of the change (transformation) of the air temperature and humidity also occupied synoptic meteorologists [11, 17], though for conditions of air masses moving over the continents.

There are a number of theoretical works devoted to a study of the transformation of air under the influence of the underlying surface, causing thermal changes or changes in humidity [1, 2, 3, 4, 12]. The investigations of E. M. Dobryšman [10] and N. I. Jakoleva [26] are the closest to the task set by us.

M. P. Timofeev [22], using an equation of turbulent diffusion, determined the quantitative side of the process of

transformation under conditions of initiation of inversion. In a study [15] carried out in 1956 by D. L. Lajxtman and M. P. Timofeev, the effect of the size of a body of water on the humidity of the air and on evaporation are evaluated.

It should be noted that the results of the theoretical investigations were not properly compared with the observed intensity of the transformation of air above bodies of water because of the small quantity of data from such observations.

The present investigation of the effect of bodies of water on the temperature and humidity of air was begun in 1952.

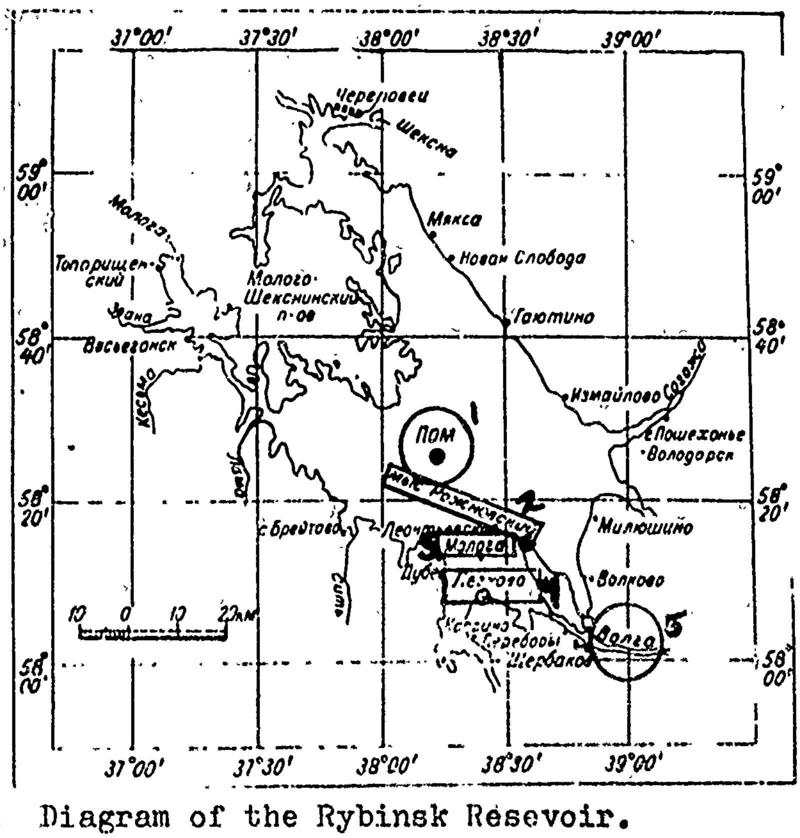
In the first stage we based ourselves on the data from standard observations (for autumn conditions) of permanent meteorological stations.

As objects of study, the Rybinsk Resevoir (having a width of about 50-60 km) and Lake Zaisan (about 90 km in length and 25 km in width) were selected. The first was chosen as the body of water closest to the Kuibyshev and Gorkii Resevoirs, and the second as an object which, although remote, was more conformable in climactic conditions to such resevoirs as Stalingrad and Tsimliansk.

At the Rybinsk Resevoir (Figure 1), it was necessary to use, besides shore stations and stations remote from the body of water, data of the Mologa station, situated 11 km from the shore at the location of an inundated city, as well. The dimensions of the islands were several dozen meters (different with different heights of the resevoir level). The height of the location of the

psychrometric box was around 3-4 meters above the surface of the water.

At Lake Zaisan, besides the stations in the steppe around the lake, data from the Topolev Cape station, located near the end of the narrow (50-100 m) sandbar jutting out into the lake, were used as well. The station was located about 3.0-3.5 km from the main shore. The bay formed by the Topolev Cape sandbar has approximately the same width (up to 4 km). The meteorological platform was located at a total height above the surface of the water of about 1.5-2.0 meters, at a distance of about 30 meters from the edge of the water on the side of the open lake, whose width in this part was about 20-30 km. At the time of the great flood in July of 1942, waves were lapping several meters from the psychrometric box.



1. Point of open sea (POM)
2. Cape Rozhnovskii
3. Mologa
4. Legkovo
5. Volga River

Figure 1. Diagram of the Rybinsk Resevoir.

The effect of the bodies of water was studied by the data of the permanent meteorological station for the period preceding the formation of ice--approximately from the moment the temperature of the water reached 4 degrees.

The changes in the temperature of the air (Δt) were studied as a function of the difference in the temperature of the water in the resevoir (T) and the temperature of the air on the land (t) for periods of 1, 7, 13, and 19 hours.

$$\Delta t = f(T-t).$$

The change in absolute humidity was studied as a function of the difference of the maximum water vapor tensions (E) saturating the air for a given temperature of the water, and the absolute humidity of the air (e) on the land for the usual times of observation.

$$\Delta e = \varphi(E-e).$$

For comparisons, the stations were chosen in pairs. At the Rybinsk Resevoir they were: 1) Mologa, which was always taken as the lake station [14] characterizing the temperature and humidity of the air above the body of water, and 2) one of the "shore," "litoral," or "continental" stations. The data for the station paired with Mologa was selected so that the wind for the period of observation was directed in a line connecting both stations. Moreover, two cases were examined: wind from the shore station toward the Mologa station, and wind from Mologa toward the station on the shore. The direction of the wind in both cases

was taken as that which was observed in this period at Mologa.

The correlations obtained at the two indicated resevoirs, not cited here for a lack of space, revealed only the general character of the changes in the temperature and humidity of the air above the bodies of water, but because of the considerable dispersion of the points in it, it was not possible to determine a definite numerical function from either factor.

For the Rybinsk Resevoir, the dispersion of the points of the relation, evidently, was caused by the great jaggedness of the shoreline, the location of several stations in the inlets and bays or near them, the severe swampiness of the land, the presence of a large number of tiny lakes, and wide (up to 5 km) zones of flooded woods and floating masses of peat. Thus, the border between the water and the land was extremely broad and undefined here, and the length of the path of the air over the water difficult to determine.

At Lake Zaisan, the fact that the station in the steppe is extremely remote from the lake evidently plays a role. The station closest to Cape Topolev--the city of Zaisan--is located 70 km away in a southeasterly direction. The other stations, even more remote from the Cape Topolev post, are located at the following distances from the lake shore nearest to them: Kumashkino about 43 km, Kumyshinka 48 km, Aksuat 52 km, and Buran 65 km.

Nevertheless, a more definite dependence was obtained for Lake Zaisan. From the size of the slope of the average line of dependence, one may roughly estimate that for a difference of

(T-t) = 10 degrees, the change in the temperature of the air between the steppe station and the station at the lake (Cape Topolev) equals 4-5 degrees. For an absolute humidity of the air corresponding to 10 millibars of deficit, the change over the water equals 2.5-4.0 millibars.

The experience gained from these investigations has shown that in order to introduce precision as an aim of the calculation of the characteristics of a body of water's effect for the period prior to freezing, as well as during the thawing of the ice, the establishing of special observations is absolutely necessary. Such observations were organized for the present study and carried out in 1952, 1953, and 1954, at a series of artificial bodies of water located far apart from one another: Kliazminsk Resevoir on the Moscow Canal, Tsimliansk and Rybinsk Resevoirs, and Lake Lenin (the Dnepr Hydroelectric Station).

The existing Methodological Instructions [16] for the preparation of the so-called "graded" observations above a water surface, devised by the State Hydroelectric Institute in 1950, did not completely satisfy the set task. Therefore, special instructions and directions, both used and the Kliazminsk Resevoir and sent to the Tsimliansk and Rybinsk observatories and to the Zaporozhye Hydrometeorological Station, were developed for the observations being carried out.

Changes in the temperature and humidity of the air resulting from the influence of a body of water were taken into account by a comparison of the data on these factors for the two opposite shores,

with winds directed from the first point of observation on the shore where the wind was blowing from the land, to the second point located on the other shore, ie, where the wind was blowing from the water.

In such a manner, changes were observed in the stream of air crossing the body of water. The changes in the temperature obtained were considered, as was mentioned above, as a function of the difference (T-t) of the temperature of the surface of the body of water and the temperature of the air on the land. Changes in the humidity were considered as a function of the difference (E-e) in the maximum water vapor tension for the particular temperature on the surface of the body of water, and the absolute humidity on the land.

The observations were conducted in series of readings: at the Rybinsk Resevoir in 4 periods, and at the others usually in three. Autumn observations were performed with an open surface on the water and a water temperature of under 10 degrees. Spring observations began while there was still an ice cover and finished after the ice had cleared.

At the Kliazminsk Resevoir, the studies were carried out with the resources of the Central Institute of Forecasting. The Kliazminsk Resevoir belongs to the system of the Moscow Canal. It is elongated in a latitudinal direction. Its length is about 15 km. The observatiors were made in the eastern, most open part, with few wooded shores (Pirogovsk Reach), where the width of the body of water is about 1 km.

In 1952, seven series of observations were made from October 17 to November 20, with a water temperature of 7.2 to 0.6 degrees, and an air temperature of 3.5 to -3.1 degrees. In 1953, 48 standard series of observations were conducted from April 3 to April 25, with a water temperature not over 10.6 degrees and an air temperature between -1.2 and 16.8 degrees; and in the period from November 6-25, 44 identical series of observations were conducted with a water temperature of 5.6-0.0 degrees and an air temperature of +4.8 to -17.4 degrees.

The observations were conducted simultaneously on the two opposite shores and in the beginning at both of the water edges as well. In the process of the work, it was found necessary to select a point of observation on the windward shore of the resevoir (ie, where the wind blows from the land toward the water), above the escarpment, near the change to the steeper slope. On the leeward shore of the resevoir (where the wind blows from the water) the equipment was set up above the water or ice at 1.0-1.5 meters from the edge or near it on the shore. The point on the northern bank was usually fixed, but on the southern shore it was situated each time in one place or another within the limits of a kilometer from the shoreline, depending on the direction of the wind. Therefore, the length of the path of the air over the water alternated between 800 and 1200 meters. The instruments were fastened onto a specially prepared moveable stand.

The temperature and humidity of the air was measured by large model Assman aspiration psychrometers suspended vertically

at heights of 200 and 15-20 cm over the surface of the ground, water, or ice. The wind velocity was measured by a hand Fuss anemometer at a height of 200 cm. The direction of the wind was determined by a Tretiakov wind gage. The temperature of the water was measured at the shore and in the middle of the resevoir by thermometers in metal cases. Cloudiness, atmospheric phenomena, the condition of the body of water (swell, ice phenomena) and of the surface of the ground were also recorded.

In each period, readings on the psychrometer were taken every 20-40 seconds, and not less often than every 1-2 minutes, continuously for 20, 60, or 120 minutes, during which the middle of the series of readings was coordinated in time. Thus, in each series there was a large number of readings (tens and hundreds). The first time of operation (with a view to establishing a proceedure) the observations were the longest.

During precipitation, observations were usually not conducted because of the difficulty in determining the influence of the precipitation.

The sensitivity of the Assman psychrometer was sufficiently large. This was clearly apparent in the instance when a small steamer, passing 100 meters from the place of observation, changed the reading of the thermometer 0.2 degrees.

From the routine of conducting continuous readings, it is observable that during overcast weather with no precipitation the temperature and humidity of the air on both shores are extremely steady (usually within the limits of 0.1-0.2 degrees, and 0.1-0.2

0.1-0.2 millibars). But with gusty winds, or with variable cloudiness, or even with clear, sunny weather (because of the unequal heating), changes take place during the entire time of the given series of observations.

The function $\Delta t = f(T-t)$ is given in Figure 2 for the autumn of 1952 (H = 200 cm).

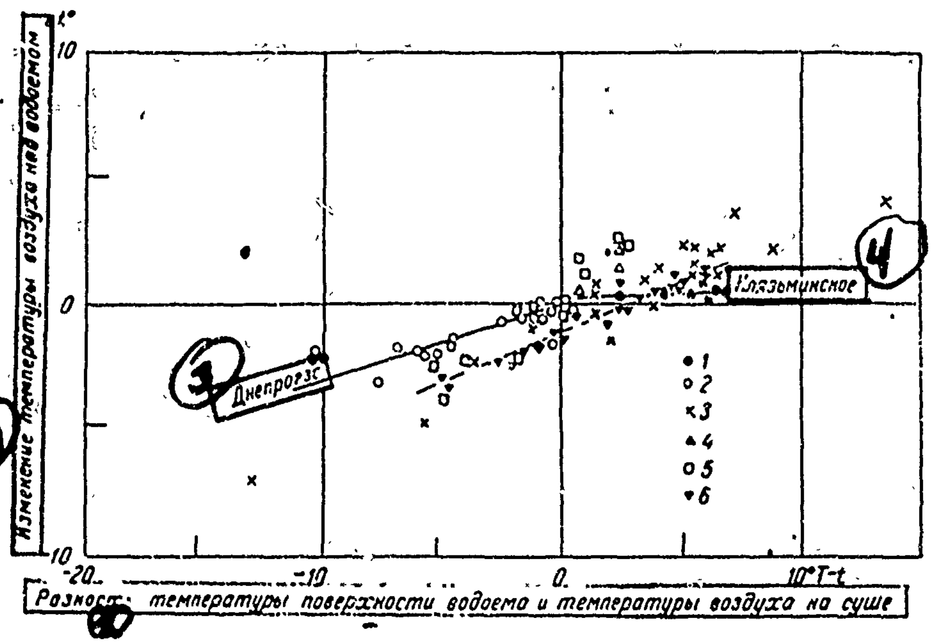


Figure 2. The function $\Delta t = f(T-t)$ from the data of special observations. 1--Kliazminsk Resevoir; 2--Lake Lenin (Dnepr Hydroelectric Station); 3--Tsimliansk Resevoir (average daily); 4--Lake Valdai; 5--Veseloe Resevoir; 6--Lake Constance (average monthly).

The changes in the temperature and humidity of the air during its passage over the Kliazminsk Resevoir were small. The temperature fluctuated by two to three tenths, and up to one half

degree. The absolute humidity of the air changed two to three tenths, for the most part within the limits of a half millibar.

The small magnitudes of the changes in temperature and humidity over the narrow (1 km in width) Kliazminsk Resevoir did not permit the effect on these elements of other factors (the wind velocity, changes in the length of the path, etc.) to be established with sufficient accuracy.

The studies conducted gave a number of procedural hints about the organization of such researches over bodies of water, which were taken into account during the organization of studies on other objects.

In particular, the Kliazminsk observations showed that the influence of a body of water on the temperature and humidity of the air is best determined by conducting experiments simultaneously on both shores. In this way the daily variations in temperature and humidity are excluded.

Let us note that during simultaneous observations occasions are possible for the incorrect determination of the influence of a body of water during a particular path of advection. For example, if in the region of the "starting" meteorological station air appeared with a different temperature and humidity, and it had not yet reached the receiving station, then the recorded divergence in the meteorological elements does not reflect the influence of the body of water.

Small variations (of 10-20 degrees) in the direction of the wind do not show up in the temperature and humidity of the air

at the "receiving" station.

To avoid obtaining "accidental" magnitudes, the observations should consist of series of readings of the temperature and humidity of the air.

1. Khoroshev
2. Primorsk

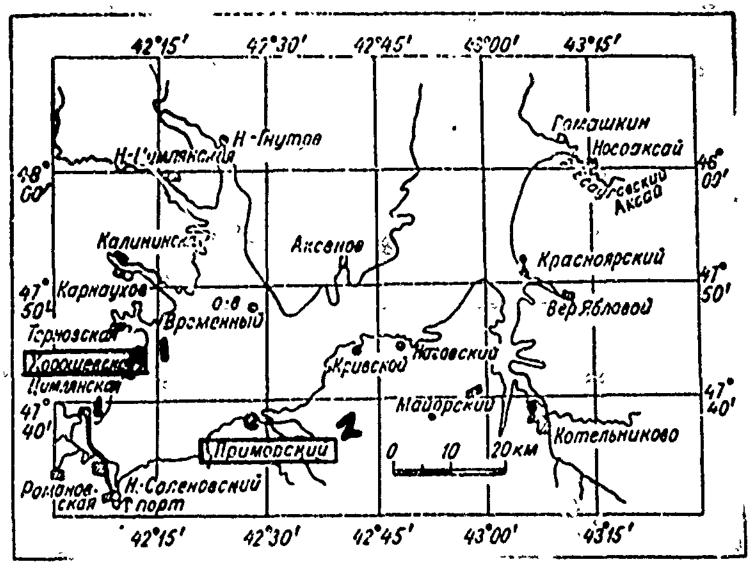


Figure 3. Diagram of the southern part of the Tsimliansk Resevoir.

At the Tsimliansk Resevoir, similar readings, at the suggestion of the Central Institute of Forecasting, were conducted with the resources of the Tsimliansk Scientific Research Hydrometeorological Observatory (TsNIGO). Observations were conducted at two fixed points, separated by a water distance of 22 km, and located on the southein and broadest part of the resevoir: on the eastern shore at the Primorsk settlement; and on the western shore at the Khoroshev station in the autumn of 1952 and in the spring of 1953, and at the settlement of Tsimliansk in the spring of 1954 (Figure 3).

With the wind from the shore, observations were made from

the upper station near the escarpment. With the wind from the water, they were made from the lower post at the smallest distance from the edge possible without the spray from the waves reaching the instruments. The psychrometers were set up in a horizontal position at a height of 150 cm (1952 and 1953), and 200 cm (1954), and the lower psychrometer always was set up at a height of 50 cm; the anemometer was set up at a height of 200 cm. The direction of the wind was determined with a streamer.

The observations were usually conducted in three periods, in series of three readings per period, and in supplementary periods when the required wind directions were observed. In 1952 they were conducted 10-15 times a day (between 7 am and 9 pm). The observations were almost always taken at identical times on both shores. Readings not synchronized were not used in the analysis.

In the autumn of 1952, observations were conducted from November 14 to December 13, with a water temperature between 6.3 and 0.1 degrees, and an air temperature from +2.2 to -18.4 degrees. In all, 380 series (of 2-3 readings) of observations were conducted. From them, after the selection of the proper directions of the wind, 162 pairs of simultaneous observations on both shores were used. From March 27 to April 19 in the spring of 1953, with temperatures on the surface (ie, on the ice, and later on the water) of the resevoir of 0.0-6.2 degrees, and of the air of -2.6 to +22.9 degrees, 122 series of observations were conducted . with continuous readings each 20-40 seconds during the course of

3 minutes, and with recordings of 3 to 5 readings. From them, after a selection of bearings, 102 pairs of observations were used. In the spring of 1954, from April 10-30, with a water temperature of 0.2 to 13.5 degrees, and an air temperature of -1.4 to 19.7 degrees, 61 observations were conducted at Tsimliansk and 77 at Primorsk. But after the selection of bearings, only 20 pairs of observations simultaneous to both shores were used.

The data of the observations used are given in Appendix 1. The position of the straight line connecting the two observation points Primorsk and Khoroshev approximately corresponds to the wind heading ESE. From Primorsk to the settlement of Tsimliansk the direction of the straight line corresponds to a wind heading of about SE (Figure 3).

Winds during the observations at the Tsimliansk Resevoir were for the most part from the eastern component and, somewhat less frequently, from the west.

During the research, data were used from observations at the two indicated points, with wind directions both along the straight line connecting the two stations, as well as in several other directions.[1] That is, instances were selected primarily with winds inside the limits of the southeastern and northwestern quarter of the horizon.

In Figure 3, it may be seen that with all headings in the southeastern quarter, the wind blows from the body of water to Khoroshev. Moreover, in this case the wind does not pass over an excessively long path along the shores of the resevoir. Shore

influences here can show up only with extreme southerly headings. For headings in the northwestern quarter, the wind brings the air only from the open part of the body of water to the Primorsk observation point. Only a purely western wind blows on a small expanse along the shore near the settlement of Primorsk itself.

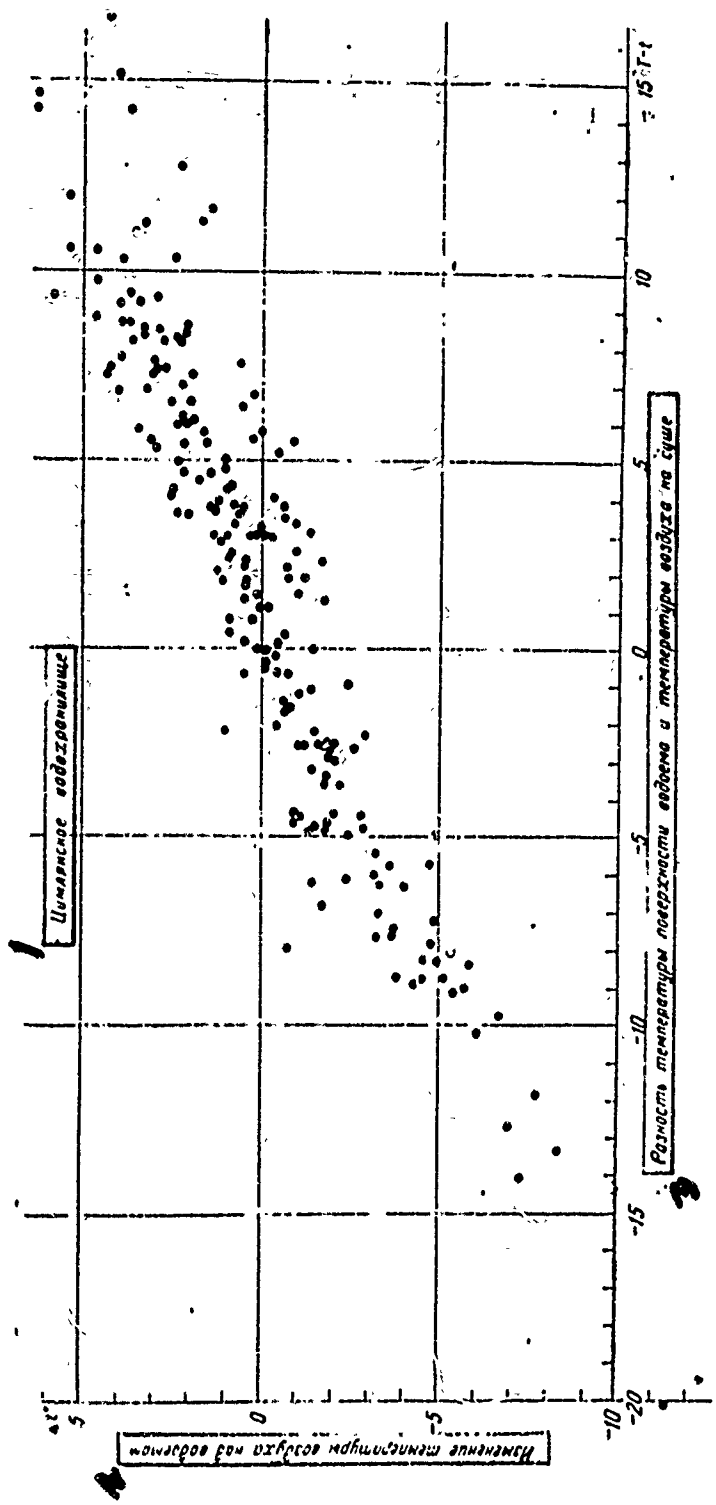
It was assumed that the observations in Primorsk characterize the conditions on the southeastern shore of the extensive southern portion of the body of water with winds from this shore. Analogously, the observations at Khoroshev reflect the conditions of the western shore under western winds.

The study of the effect of the Tsimliansk Resevoir in the autumn of 1952 on the temperature of the air was conducted at first from the data of observations with winds only from the southeastern quarter.

The function $\Delta t = f(T-t)$ was obtained with a rather narrow range to the scattering of the points, and passing through the origin of the coordinates (Figure 4). With an increase in the difference of the water-air temperatures, the increment of the air temperature above the body of water, in relation to the air temperature over the land, also increases.

According to the data for winds from the northwest quarter, the same effect of the body of water was established as in the cases of southeasterly winds. Both of the graphs for winds of southeasterly and northwesterly headings give a comparable spread of points.

In contrast to the results of research on the Kliazminsk Resevoir, where the effect of the body of water on the temperature



1. Tsimliansk Reservoir
2. Change in the temp. of the air over a body of water.
3. Dif. in the temp. of the surface of the body of water and the temp. of the air on the land.

Figure 4. The function $\Delta t = f(T-t)$ from the data of special observations.

was measured in tenths of degrees, here it was established that the wide Tsimliansk Resevoir caused temperature changes of several degrees.

Let us point out that the water temperature used in determining the difference (T-t) was the average measured on both shores.

While conducting the research on the effect of a body of water on the temperature and humidity of the air in the spring of 1953, complications arose in determining the temperature on the surface of the resevoir.

With a solid ice cover, the temperature of the surface of the body of water was, for lack of special measurements of the temperature of the surface of ice, conditionally taken as equal to the temperature of melting ice, ie, 0.0 degrees.

The ice cover, however, was not present on all days observations were made.? From all the data possessed, including sketches of the ice condition on both banks and aerial reconnaissance maps of the ice made on April 5, 7, 14, 15, and 17, 1953, the percentage of free water surface area (P) was roughly estimated. For the section of the resevoir between Khoroshev and Primorsk, it was taken as equal to the magnitudes shown in Table 1.

Table 1

Date	Water area (%)	Date	Water area (%)
27/III–10/IV	0	16/IV	75
11/IV	10	17/IV	85
12/IV	35	18/IV	90
13/IV	40	19/IV	95
14/IV	50	20/IV	100
15/IV	65		

Температура поверхности водоема при наличии льда и воды одновременно была подсчитана по формуле

$$T = \frac{n}{100} \cdot \frac{T_x + T_n}{2},$$

The temperature on the surface of the resevoir with the simultaneous presence of ice and water was calculated by the formula

$$T = \frac{n}{100} \cdot \frac{T_x + T_n}{2}$$

where T_x is the temperature of the water at Khoroshev, and T_n is the temperature of the water at Primorsk (at the shore).

In the spring of 1954, the ice conditions were comparitively uniform. The period of stable ice on the broad part of the resevoir which interests us lasted until April 20; on April 21, all of the resevoir above the dam cleared itself of ice.

For the days of April 10-17, 1954, during the presence of a solid ice cover, the temperature of the surface of the resevoir was taken as equal to zero degrees.

On April 18, 19, and 20, the direction of the wind was such that the possibility did not exist of making comparisons of the thermal nature of the land and water. During comparisons for the dates following, the water temperature was taken as the average of the findings of measurements on both shores.

As a result of an analysis of the 1953 and 1954 spring observations, the function was obtained (the left half of Figure 4)

$$\Delta t = f(T-t).$$

The breadth of the field of points and their spread has just the same character as for the autumn.

The function $\Delta t = f(T-t)$ for the autumn and spring is given

in Figure 4. The autumn data occupy the upper right-hand part, and the spring the lower left.

In the spring, the air above a body of water covered with ice or still having a low water temperature is, in the majority of cases, colder than over land. Moreover, the rate of cooling of the air in the spring is greater than its rate of warming in the autumn.

These functions indicate that the difference in the periodical air temperatures over land and over water can attain large values, especially in the spring.

Thus, in 1952 the temperature of the air was: at the shore on November 15, -6.4 degrees; on October 16 at 7 am, -5.6 degrees, at 9 pm, -4.4 degrees; and on November 22, -6.0 degrees; and above the body of water itself, -0.9, -0.1, -0.5, and -1.3 degrees respectively.

In the spring of 1953 the air temperature was: at the shore on the afternoon of April 11, 17.0 degrees; and on April 18, 22.9 degrees; and above the body of water, 9.0 and 10.5 degrees respectively.[3]

The function $\Delta t = f(T-t)$, as indicated above, gives a certain spread of points. It is caused by the fact that in the changes of air temperature not only the difference $(T-t)$ shows up, but so do other factors, in particular the length of the path of the air over the water, the velocity of the wind, etc., examined below.

In the survey of the literature, cases were cited of

significant differences in the average daily and monthly temperatures of the air, caused by bodies of water. It was natural to expect even larger differences for individual periods, which was confirmed during our research.

Changes in the absolute humidity of the air over Tsimliansk Resevoir were investigated analogously to the study of the changes in the temperature of the air.

The research revealed the existence of the linear function (Figure 5)

$$\Delta e = \varphi(E-e).$$

With an increase in the value of (E-e), the change in the absolute humidity increases with the movement of the air over the resevoir.

It was established as a result of the research that the increment in the humidity is, comparitively, somewhat less than in the temperature, but is still large, and is measured in many percents and tens of percents of the observed deficit. The right half of Figure 5 represents the autumn processes of the moistening of the air over the warm surface of a body of water, and the left relates to spring conditions, representing the negative magnitudes of the deficit of humidity[4] and, accordingly, the decrease over the body of water of the absolute humidity of the air relative to the land. Consequently, the colder air over the body of water usually contains less water vapor than the air on the land.

The spread of the points in the function $\Delta e = \varphi(E-e)$, as in the case of t, is caused by the action of such factors as the

length of the path, the velocity of the wind, etc. Let us note that a small number of points in the autumn data fall on the left half of the graph in the case of increases in temperature. And, conversely, for cases of cooling in the spring, some of the poin are located on the right half of the graph.

Analogously, a small number of the autumn data on humidity fall on the left and spring data on the right half.

In the distribution of points of the functions $\Delta t = f(T-t)$ and $\Delta e = \varphi(E-e)$, the following details may be noted.

The characteristic trait for the spring, compared with the , is a somewhat greater slope of the function, first noticed)ining the fall and spring data in a single diagram (Figure 4).

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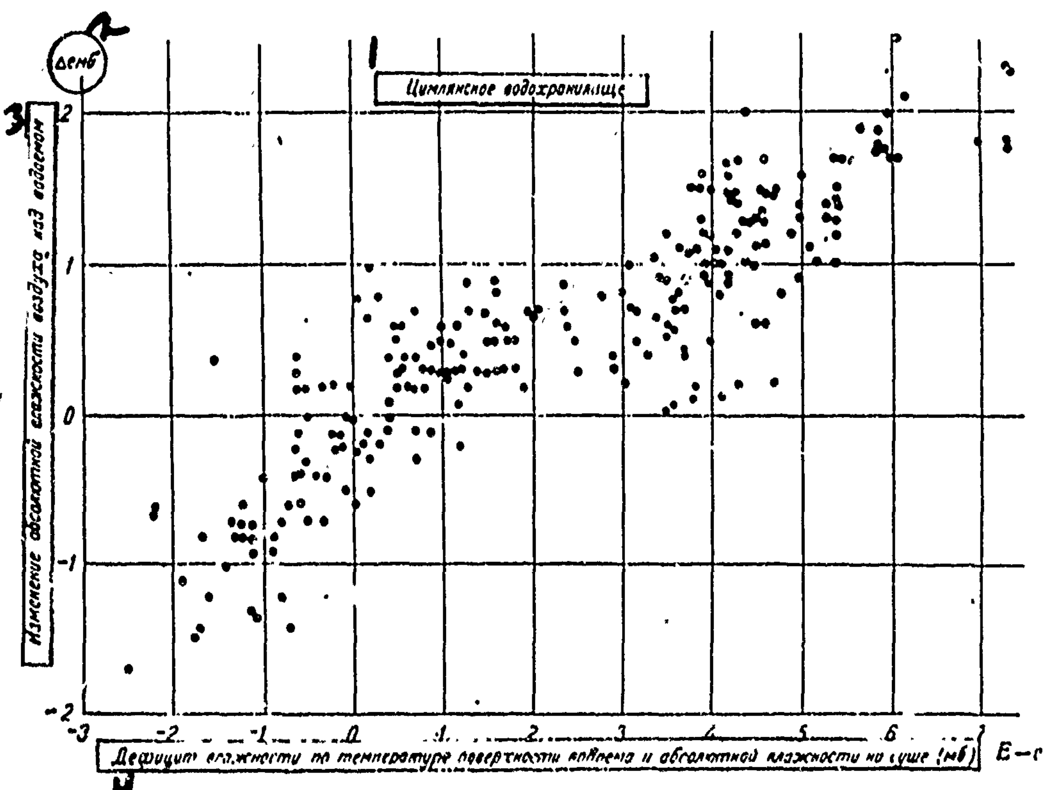


Figure 5. The function $\Delta e = \varphi(E-e)$ from the data of special observations.

The presence of points supposedly showing the warming of the air over a cold body of water and its cooling over a warm one may be explained by the roughness of the discovered function, in as much as the spread of points occurs within the limits of ±2 degrees and ±1.0 degrees; and 0.5 millibars. The cause could also be an insufficiently consistent procedure.

The greatest rate of cooling of the air in the spring, which causes the steepness of the left half, might be explained by the fact that the warm air coming from the shore, upon cooling over the body of water, stagnates, and its turbulence is decreased, which gives the greatest difference of t for equal values of (T-t). An increase in the surface temperature of the water may also play a certain role in this; it is measured at the shores, and in the spring the water there warms faster than in the body of water as a whole.

The slope of the left half of the function $\Delta e = \varphi(E-e)$ (Figure 5) is greater than on the graph of the changes in the air temperature. Besides the influence of the factor just noted, the greater slope of the left (negative) half of the function may be explained by the simultaneous condensation of water vapor on ice (or on the surface of cold water), and also in the lower layers of the air (the formation of mist over the body of water).

Let us point out that the conditions for the change in the temperature and humidity of the air are in general somewhat different. In the movement of air over a body of water, vertical displacements occur as well. The sinking air warms up, which

decreases the effect of the cooling of the air over the body of water. The sinking air cannot obtain an additional quantity of water vapor or lose it. Therefore it is to be expected that the graph of cooling of the air will proceed more steeply than the graph of the decrease in the absolute humidity.

The extremely slanted distribution of the points at zero may be explained by the fact that with small values of (T-t) and (E-e), the effect of the "secondary" factors not considered by us appears.

At the Rybinsk Resevoir, observations specially set up for the present study were conducted by the Rybinsk Hydrometeorological Observatory in the autumn of 1953, in the southern part of the resevoir (Figure 1), at points Legkovo and Cape Rozhnovskii (on the northwestern end of Varaksin Island). The psychrometers were errected vertically at a height of 15 and 20 cm. The direction of the wind was determined by a Tretiakov wind gage. Furthermore, for the present study data were used from observations from the so-called Point of Open Sea (POM), situated to the north of the broad part of the body of water.

The observations were conducted in 4 periods (at 1 am, 7 am, 1 pm, and 7 pm): at Legkovo on October 14-22 with a water temperature (T) of 8.7 to 0.0 degrees, and an air temperature (t) of + 12.0 to -9.8 degrees; at Rozhnovskii on October 22-November 23 with T from 7.1 to 0.0 degrees, and t from +7.4 to -10.2 degrees; and at POM on October 9 through 31, with T from 7.2 to 3.4 degrees, and t from +9.3 to -7.1 degrees.

For the Legkovo-POM pair of stations, there are data for simultaneous observations from October 14 through 31 (73 periods), and for the Legkovo-Rozhnovskii pair from October 22 through November 22 (80 standard observations). The POM-Rozhnovskii pair is not representative, and the observations are short-term (October 22-31).

The Rybinsk Reservoir, from the point of view of the possibility of a study of changes in temperature or humidity of the air, represents a special object. At it, it was in general extremely difficult to select for setting up observations two points suitable to the present task of calculating the effect of a body of water on the temperature and humidity of the air. The configuration of the resevoir, its shoreline, and conditions near the shore are excessively unusual [13, 20].

The comparison was made from the data of the Legkovo and POM points with a southerly wind heading. The straight-line distance between these points was equal to approximately 45 km[5]. The other observed wind headings do not permit simultaneous comparisons of the temperature and humidity of the air, representative of the land and the body of water, at Legkovo and POM.

In order to supplement the data, cases were also used when the direction of the wind was not exactly along the straight line joining Legkovo and POM, but at a sharp angle with it. Altogether, to plot the function for Legkovo and POM in Figure 6, 13 instances with identical wind directions at both points of observation were used, 17 cases with wind directions differing by an angle of 22.5

degrees, 8 cases with an angle of 45 degrees, and two cases with 67.5 degrees.

1. Changes in the temp. of the air over a body of water.
2. Dif. in the temp. of the water and the air on the land.

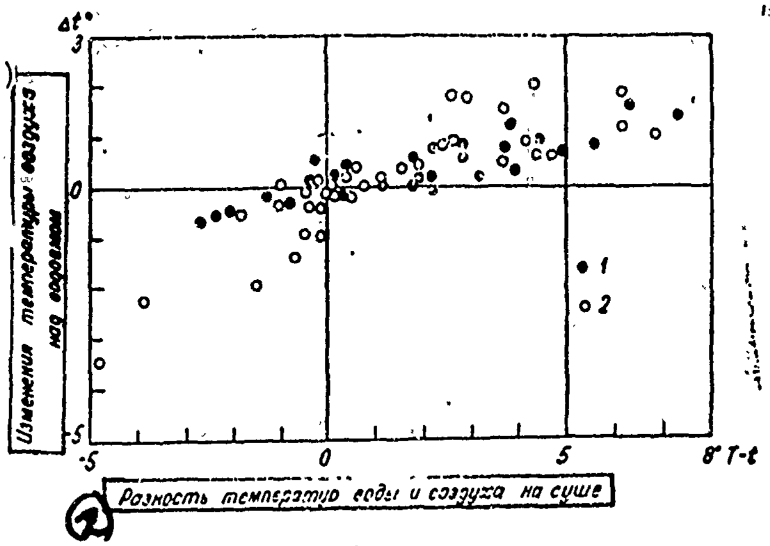


Figure 6. A graph of the function $\Delta t = f(T-t)$ from special observations at the Rybinsk Resevoir. 1--Legkovo-Rozhnovskii; 2--Legkovo-POM.

The data for the Legkovo-POM stations gave a function with a slope greater than for the corresponding distances at the Tsimliansk Resevoir. The range of magnitudes of the independent variable (T-t) and of the increments in t are smaller here than in the south.

Data from the Legkovo and Cape Rozhnovskii points of observation were used for southerly headings when at Legkovo the wind was blowing from the land, from the penninsula, and at Rozhnovskii when it was blowing from the water. The function $\Delta t = f(T-t)$, presented in Figure 6, where the position of the average plot of the function, under conditions of the warming of the air are approximately the same as by the Legkovo-POM data, was obtained. The function for instances of the cooling of air over

a body of water in the autumn diverges noticeably. For these conditions, however, there is little data to confirm the validity of the divergence.

The above-shown peculiarities of the functions obtained by observations at the Rybinsk Resevoir may be explained in that, given the conditions of the Tsimliansk Resevoir, with substantial warming at the shore the range of temperatures should be greater than with a lesser degree of warming in the north. The difference in the character of the shores (a dry, high, sandy shore at the Tsimliansk Resevoir, and a low-lying, swampy shore at the Rybinsk Resevoir), evidently, shows up in the steeper slope of the function $\Delta t = f(T-t)$ for the Rybinsk Resevoir in comparison with Tsimliansk.

At Lake Lenin, in the rayon of the Dnepr Hydroelectric Station, observations were conducted from March 3 through April 16, 1954, according to the program of the Central Institute of Forecasting. The points of observation were situated on the right (western) and left (eastern) shores. The temperature of the water in the period of observations fluctuated between the limits of 0.0 and 3.4 degrees, and the temperature of the air between -7.2 and +15.7 degrees.

For the aims of the research, observations were selected from the data obtained with winds of approximately latitudinal direction, in which air from one point was received at the other. The distance between the windward shore of the lake and the point of observation on its leeward shore with these headings was equal to 1.5-2.5 km.

The data for $\Delta t = f(T-t)$ is plotted in Figure 2.

In the same diagram, data are cited for analogous observations (conducted at the request of the Central Institute of Forecasting) at Lake Valdai and at Veseloe Resevoir (with data from the State Hydrometeorological Institute). The points lay close to the average curve of the base graph, ie, the presence of the discovered function is affirmed by the data of this body of water as well.

For our purposes, we also used data from the previously cited study by R. Marqvardt [27] at Lake Constance. Measurements of temperature and humidity were conducted there with the aid of a ship's psychrometer, installed in the ventilation chamber of the meteorographs in the fore part of the deck of the ship at a height of 240 cm above the water. Observations were conducted only with the intake of air from the front. To supplement these basic observations, on a support jutting out of the bowsprit one meter to the side, a self-recording electric telethermometer was set up, situated in a stream of air unperturbed by the hull of the ship.

The direction and velocity of the wind were determined by means of changing the course of the ship until the smoke from the stacks began to rise vertically. In this case, the direction and velocity of the ship corresponded to the direction and velocity of the wind over the lake.

Self-recording instruments were set up on the shore.

The fundamental difference of Marqvardt's data from the others used in the present study consists in the fact that the observations were not synchronous. Readings were conducted in

proportion to the degree of the ship's withdrawal from the shore, and were compared with the "initial difference" in the water-air temperatures. The length of the majority of the observations was about 15 and 20 minutes. Marqvardt cites data not only for spring and autumn observations, but also for a number of other months of the year, excluding January, March, and August.

The function of the changes in humidity $\Delta e = \psi(E-e)$ gave a large scattering of points. It evidently results from the insufficient accuracy of the readings of the self-recording instruments and from the lack of simultanity in the observations on the shore and the water. Unfortunately, in Marqvardt's article data are not cited for synchronous comparisons (although the self-recording instruments were operating). Such a comparison would probably give considerably better results.

For a distance of 11.7 km, Marqvardt obtained a value for the increase in temperature of 27% of the average initial difference (T-t), which accords with the data obtained by us. For 0.9 km, according to Marqvardt, the changes are 14%; this is greater than from our data for Kliazminsk Resevoir.

V. Peppler [29] used a large number of the same Lake Constance observations. From his average monthly morning and afternoon multi-year data, the author constructed a graph of the function $\Delta t = f(T-t)$ (Figure 2). The average monthly data for Lake Constance gave a narrow spread of points on the graph, which is certainly a result of the averaging. The field of points has approximately the same slope as in the functions obtained by us,

but lies lower in its average curve. This is apparently caused by the fact that the average monthly values reflect, of course, not only the instances of the wind blowing from the shore to the body of water, but also the reverse directions of the wind from the body of water to the shore.

The average daily increments in the temperature of the air over Tsimliansk Resevoir were also investigated for "pure" cases, ie, with wind directions from the land to the body of water.

The data according to average day turned out very scanty since it was necessary to throw out those days in which the direction of the wind didn't satisfy the required condition in even a single period.

The points lay on the average curve of the field of the graph in Figure 4, ie, showed a more precise function than did the periodical values.

The enumerated data from the observations specially conducted for the present study were used for the research on the effect of such factors as wind velocity (on which depend the rate of turbulent intermixing and the time of the passage of the air over the body of water), as well as the length of the path from the windward shore of the body of water to the point of observation on the leeward edge of the water.

S. I. Rudenko [18], analyzing from the Marqvardt data the changes in humidity under various wind velocities, notes: "It is remarkable that whatever the velocity of the wind, at the terminal point of observations the enrichment of the air by water vapor was

approximately the same. A similar phenomenon was noticed by us at other lakes. . . . Tracing the enrichment in water vapor from one shore station to two other island stations, it was noted that the air picked up . . . the same quantity. . , but with high wind velocities in a shorter period of time and with low velocities in a comparitively long period of time."

Our data do not confirm this.

The function $\Delta t = f(T-t)$ described in the present study was analyzed in terms of the wind velocities plotted in it.

It was noticed that the points corresponding to the greatest wind velocities were located only in the center of the graph near the origin of the coordinates, ie, they show small changes in temperature for small values of the independent variables.

Furthermore, according to the data for observations at the Tsimliansk Resevoir, the velocity of the wind $\underline{v}$ was compared with the magnitudes of

$$\frac{t}{T-t};\ \frac{t}{t_n}$$

(here t_n is the temperature of the air on the windward shore of the body of water). The spring data for 1953 show an increase in increments with a growth in the wind velocity. Other data, however, do not support this. For example, for the small Kliazminsk Resevoir a decrease in the increments of t/t_n with a growth in the wind velocity is more definitely noticeable.

A classification of the data of $\Delta t = f(T-t)$ and $\Delta e = \varphi(E-e)$ by wind velocities charted the minimal value of increments of

$t/(T-t)$ for a range of wind velocities from 3.1 to 5.0 m/sec for autumn conditions. With an increase of decrease in the wind velocity, the value of $t/(T-t)$ rose. The velocity was observed up to 11.9 m/sec.

For spring conditions, $t/(T-t)$ has a minimum in the range 0.0 to 1.5 m/sec and rises with an increase in the wind velocity.

The change in the humidity of the air and in the ratio $e/(E-e)$ occurs in approximately the same way.

Thus, for increments of the temperature and humidity, a certain tendency begins to appear for a change in sign of the effect of the velocity. Up to 5 m/sec, a decrease in the increments with an increase in the velocity is observed. With a further increase in the velocity, the increments in temperature or humidity rise.

On the whole, the picture of the effect of the wind velocity is, evidently, quite complex. The data from the observations conducted do not give a reliable numerical function for the changes $t/(T-t)$ and $e/(E-e)$ in relation to the changes in wind velocity.

In a recently published study [9], L. S. Gandin, using the studies of M. E. Shvets [23 and 25], comes to a conclusion about the small growth of the magnitude of evaporation even with an increase in the wind velocity of twice, and about the large effect of turbulence. With an increase in the wind velocity and an identical (relative) decrease in the coefficient of turbulence, evaporation follows the latter, ie, diminishes.

It follows from this that the latest theoretical works of research on the effect of wind velocity on heat exchange by evaporation do not show its analogous function. Evidently, the

wind has the same effect on the change of temperature and humidity of the air over the body of water as well.

The change of air temperature and humidity above a body of water is more clearly discernable in connection with the dimentions of the water surface of the latter or, what is the same, with the length of the path of the air over the water.

At Tsimliansk Resevoir, as was indicated earlier, the point of observation at the settlement of Primorsk represents the temperature and humidity of the air on the southeastern shore, and the point at Khoroshev on the western shore within the limits of the broad southern part.

The length over the water from the various points on the windward shore of the resevoir to the observation point on its leeward shore differs depending on what path (considering them to be straight lines) the air stream moved along with different headings of the wind.

Winds from the south-eastern quarter of the horizon travelled away from the opposite shore toward Khoroshev from a zone within the limits of a right angle between the spot located directly to the east of Khoroshev, and a spot located to the south of this observation point.

This same "fan" of headings from the western shore merged at the Primorsk point within the bounds of the northwestern quarter (reckoning from this point).

Rather frequently, the direction of the wind in one and the same period differed in Primorsk and Khoroshev. In this case it

was unclear what distance the wind had passed over the body of water. The average distance obtained from both headings was used.

In the general function $\Delta t = f(T-t)$, the lengths of the paths were indicated near the points for each given instance. For specific ranges of distances (10-17, 18-19, 20-23, 24-26, 27-32, 33-34, and over 35 km) the curve of $\Delta t = f(T-t)$ was plotted.

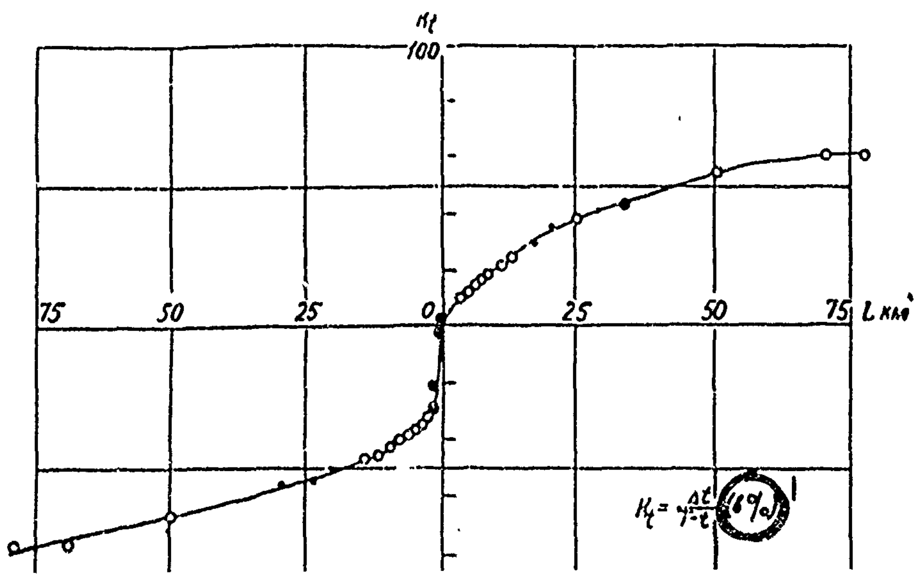
It is necessary to note that the groups by gradations were not obtained strictly delimited, but although the points of each group are found mutually within the limits of the adjacent groups, it was possible to generalize each group by an average curve. A system of straight lines was obtained, emanating from the origin of the coordinates and corresponding to the various lengths of the air paths over the water. For Kliazminsk and Dneprovskoe (Lake Lenin) Resevoirs, fixed distances were taken between the stations on both shores--1.0 and 2.5 km respectively, and obtained from a singular linear function $\Delta t = f(T-t)$. This was done for the reason that for small variations of distance--within the limits of $\pm$200 meters--the effect of the distance was not appreciable. On the basis of these functions, linear tangents were derived with angles of inclination (values of K_t) for various distances. Separately (Figure 7) was constructed the graph of $K_t = F(L)$, showing the changes in the temperature of the air in relation to the length of the path over the body of water.

In the investigation of the changes of the absolute humidity of the air, the data on the graph $\Delta e = \varphi(E-e)$, with the

lengths of the distances inserted near them, permitted the demarkation of the following ranges for the positive (autumn) part of the function: 19-20, 21-25, 26-30, 31-35 km; and for the negative (spring): 12-15, 16-18, 19-22, 23-30, and 31-35 km. The dependence of K_e on the length of the path $\underline{L}$ is shown in Figure 8. The changes in absolute humidity above the narrow Kliazminsk and Dneprovskoe Resevoirs were insignificant and gave a great spread of the points of $\Delta e = \psi(E-e)$. Therefore they were used in Figure 5.

The resulting functions $K_t = F(L)$ and $K_e = \phi(L)$ recall the functions $\Delta t = f(T-t)$ and $\Delta e = \psi(E-e)$. The larger increase in K_t and K_e in the spring shows a greater change in temperature and humidity of the air over a cold surface, than for the autumn period over relatively warm water. Changes in temperature and humidity take place more sharply at the beginning of the transit, approximately in the first twenty kilometers. Further on, the changes are not great. The negative deficit of humidity quickly disappears over a cold surface and becomes equal to zero at approximately 30-35 km from the shore. The basic causes of this were examined in the analysis of the function in Figure 5.

Figure 7. The change in the temperature of the air over a body of water with distance



(In %)

Besides the factors examined, other causes undoubtedly have an effect on the difference in the temperatures and humidity of the air on both shores. In particular, the difference in heights of measurement at the shoreline and over the water has an effect. At the Tsimliansk Resevoir at Khoroshev, with a westerly wind from the land, observations were conducted at a height of 40 meters above the water, and at Primorsk, with an easterly wind, at 10 meters. The difference in the heights of the points of observation with westerly winds at 40 meters should show up (under the adiabatic process of the sinking of the wind) in the temperature by an increase of approximately 0.4 degrees. Let us note that the changes in the temperature of the air under the influence of a body of water were expressed in many degrees. Therefore this circumstance would have consequences for a small body of water.

In the observations at Kliazminsk Resevoir, the effect of the sun--more precisely, of the illumination of the locality by the sun--was noticeable. With uniform illumination by diffused radiation in overcast weather, extremely smooth, gradual changes in temperature and humidity take place, ie, there are no sharp jumps in the differences of the magnitudes of the temperature on both shores. In sunny weather, with strong unequal heating of the soil, considerable fluctuations in the differences in temperature (and humidity) were observed.

It is not excluded that the aspiration psychrometer gives a certain augmentation to the temperature of the air with intense

solar radiation, and its readings therefore fluctuate especially noticeably with variable cloudiness, not synchronously on both shores if the sun is shining on one of them but on the other it is covered at that moment by clouds.

In determining the absolute humidity with an Assman psychrometer, errors often arise because of insufficient ventilation. It is possible that during the present research such distortions of the absolute humidity took place as well.

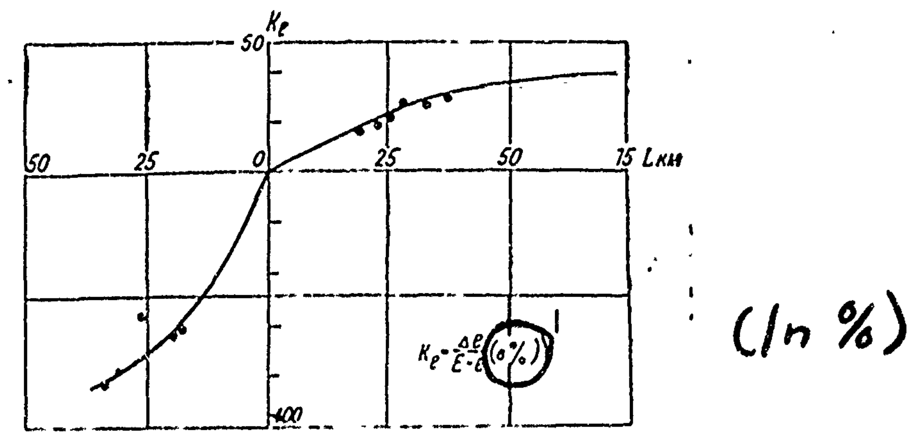


Figure 8. The change in the absolute humidity of the air over a body of water with distance.

Finally, differences in the character of the underlying surface at the "starting" station (snow,[6] dry or moist soil), which were not considered in the present research, could have had a noticeable effect on the change in temperature and humidity of the air on both shores.

In spite of the presence of a certain dispersion of the points in the resulting functions $\Delta t = f\ (T-t)$ and $\Delta e = \psi(E-e)$,

it is possible to use the functions found with an accuracy in the order of ±2 degrees or ±1 millibar.

Let us note that with an amplitude A for t equal to 18.8 degrees, an error of about ±2 degrees falls within the margins of about 10% of the amplitude (10.6%). For Δe with an amplitude of 6.2 millibars, errors of 0.5 or 1.0 millibars give amplitudes of 8.1 and 16.2% respectively, ie, less than 1/5 A.

The elicited functions $K_t = F(L)$ and $K_e = \phi(L)$ permit the evaluation of the effect of the size of a body of water on the temperature and humidity of the air moving over it.

Use of the Theoretical Formulas

The materials from specially organized full-scale observations obtained for the present research was also used to check the possibility of using existing theoretical formulas, proposed for calculations of the effect of a body of water on the temperature and humidity of the air.

The most detailed question about the change in the air over bodies of water was solved in the study of N. I. Jakoleva [26] indicated above. During the study of the changes in humidity above bodies of water, changes in the temperature of the water as a result of evaporation were investigated in this study as well, ie, a more complete physical project was applied.

However, during the use of N. I. Jakoleva's methods, the application of extremely complex calculations proved unavoidable, without giving, moreover, any advantages in accuracy (particularly

for small changes in temperature and humidity) in comparison with the computations of the less complex procedure propo: d by E. M. Dobryšman [10].

Using the methods of M. E. Śvec [24] for solving problems of the boundary layer, E. M. Dobryšman obtained a solution of the equation of the transformation of moving air under the influence of the underlying surface. In one of the problems, the author examines the steady-state process. In this case, characteristics of the underlying surface were taken as different in different places. The observations carried out by us on bodies of water also conform to the steady-state process, during which the observations were carried out at two points over a varied underlying surface.

In particular, a solution is given by E. M. Dobryšman to the equation for the change in _--the coefficient of transformation of the temperature (and humidity) of the air:

$$v_0 \ln\frac{z+z_0}{z_0}\frac{\partial \tau}{\partial L} = C\frac{\partial}{\partial z}(z+z_0)\frac{\partial \tau}{\partial z}$$

for the conditions

$$\begin{array}{ll} L = 0 & \tau = 0 \\ z = 0 & \tau = F(L) \\ z \to \infty & \tau \text{ is finite,} \end{array}$$

where L and z are the horizontal and vertical coordinates. For the data examined in the present study, this corresponds to the distance between the two stations and to the heights of 1.5 and 2.0 meters at which the psychrometer was erected over the underlying surface; z_0 is the parameter of roughness; C and v_0

are positive constants denoting the rapidity of the change by the amplitude of the coefficient of turbulence, and the velocity of the wind.

The quoted equation describes the steady process of temperature transformation (or changes in humidity) of the air due to the turbulent exchange. The coefficient τ indicates the rate of transformation.

The author gives the solution in dimentionless magnitudes; for that frequent case when $F(L)$ = constant = 1, it may be presented in the form

$$\tau(\xi,\eta) = 1-\frac{\delta^{1}}{\delta^{3}}[\eta(\delta-2+2)e^{\delta}-(\eta^{2}-4\eta+6)e^{\eta}+6],$$

where $\tau = \frac{t}{t_0}$; $\xi = \frac{C}{v_0 z_0}L$; $\eta = \ln\frac{z+z_0}{z_0}$; $\delta = \delta(\xi)$ - the thickness of the bounda layer, which is calculated in the course of solving the problem.

For the frequent case when $f(\xi) = 1$, there is an exact solution.

Thus, as a calculating device, an approximate solution is used of the equation of turbulent heat conductivity for the steady process, with a linear (by height) coefficient of intermixing, and a logrithmic elevation of the wind.

E. M. Dobryšman cites a table with a comparison of values of the independent variables $\tau(\eta, \xi)$, calculated both by the exact solution and by the formula suggested by him. Here it is shown that the precision afforded by the approximate formula is sufficient even for small magnitudes of the indenendent variable,

where the method used gives the largest error.

The author cites values of $\tau(\eta, \xi)$ from 0.911 to 0.29: for magnitudes of τ in the limits of 0.911-0.64, the absolute error falls within the range of 0.000 to 0.010; for τ - 0.580-0.56, it falls within 0.010 to 0.030; and only for a range of τ = 0.42-0.25 is it equal to 0.040.

The factual data on the transformation of the air, described above, was compared by us with the theoretical calculations of Dobrysman. In the calculations, the temperature of the surface of the body of water and the temperature of the air over the land at the height in question were assumed to have been observed. The width of the body of water was also known. Multiplying the difference in the temperature of the water and the temperature of the air on the land (moving from the shore) by the magnitude τ, we obtain the magnitude of the increments (positive or negative) in the air temperature after its passage over the body of water

$$\Delta t = \tau(T-t).$$

Or, in exactly the same manner, multiplying by τ the magnitude of the deficit of humidity d, taken at the maximum water vapor tension E over the body of water at the temperature of its surface and at the absolute humidity e on the land, we obtain the magnitude of the change in humidity over the body of water

$$\Delta e = \tau(E-e).$$

For the simplification of the calculations by the formula adopted, the nomogram $\tau(\eta, \xi)$ was constructed by Dobrysman (Figure 9). On the nomogram, the magnitude τ is found in the following

manner. From the data of the wind velocity (v), say, 4 m/sec (for a swell of second or third degree), and from the distance (L) from the shore, for instance, 10 km, we connect with a line the two points defining these magnitudes on the scales. We extend this straight line to the horizontal axis ξ. From here we construct a perpendicular, drawing it upward to the horizontal line, corresponding to the height (z) of the changes in the temperature of the air, for instance, 50 cm. The location of the point of intersection of the drawn perpendicular with this horizontal line will give us the magnitude $\underline{\zeta}$, which we interpolate between the two curves of its values. In the given example, the point found corresponds to a magnitude of $\underline{\zeta} = 0.48$. Consequently, the difference (T-t) should be multiplied by 0.48. The product gives the magnitude of the increment of air temperature over the body of water in comparison with the magnitude which the temperature of the air had over the shore, as follows from the expression $\Delta t = \zeta(T-t)$. With the data for the magnitudes (T-t), $\underline{L}$, and $\underline{v}$ from the field observations at the Tsimliansk and Kliazminsk Resevoirs, values of $\underline{\zeta}$ were calculated with the help of the nomogram (Figure 9).

With positive increments in the temperature of the air, the magnitude of the computed multiplier $\underline{\zeta}$ for air path distances over Tsimliansk Resevoir from 12 to 40 km and a measuring height of 150 cm fluctuates within the limits of 0.36-0.45. For the same field data, in the empirical graph of the function $\Delta t = f\ (T-t)$, the average line of the range of points is sloped so that $\underline{K}$ is equal to about 0.38-0.42, ie, almost equal to the values of $\underline{\zeta}$. For a cooling

of the air, the observations give a sharper slope of the function $\Delta t = f\ (T-t)$, ie, a sharper drop in the temperature of the air (K equal to about 0.55) than Dobrysman's formula gives.

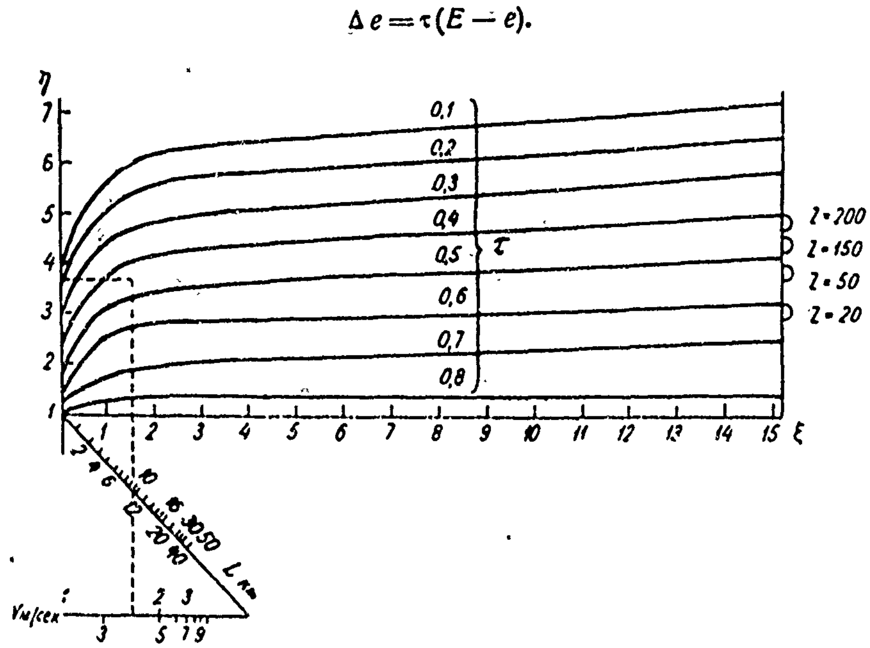


Figure 9. Nomogram ($\tau\eta, \xi$) for determining the increments in temperature and humidity of the air over a body of water; τ is the multiplier for the calculation of the increments in temperature and humidity of the air over a body of water; η and ξ are dimensionless coordinates for height and distance; v is the wind velocity (in m/sec); L is the distance (in km); z is the height above the surface of the soil or body of water (in cm); $\supset$ is the limit of the range of the magnitudes of τ.

In Figure 10, the magnitudes of the transformation obtained by calculations according to the theoretical formula are compared with factual data from field observations. This diagram gives the clearest idea of the similarity, and shows the possibility of using the results of a theoretical solution of the problem for

calculations. The slope of the average line in the correlation of the calculated and factual magnitudes shows that the data for the warming period of a body of water (spring melting) corresponds worse than for the cooling of the body of water (autumn). In the first case, tg β is equal to 0.7-0.8--in which we obtain the smaller by theoretical calculations--and in the second it is about 1.

From the nomogram (Figure 9) it is possible to determine how, in the theoretical solution, the effect of the wind velocity and the distance is evaluated in the transformation of the air.

1) Calculated
2) Observed

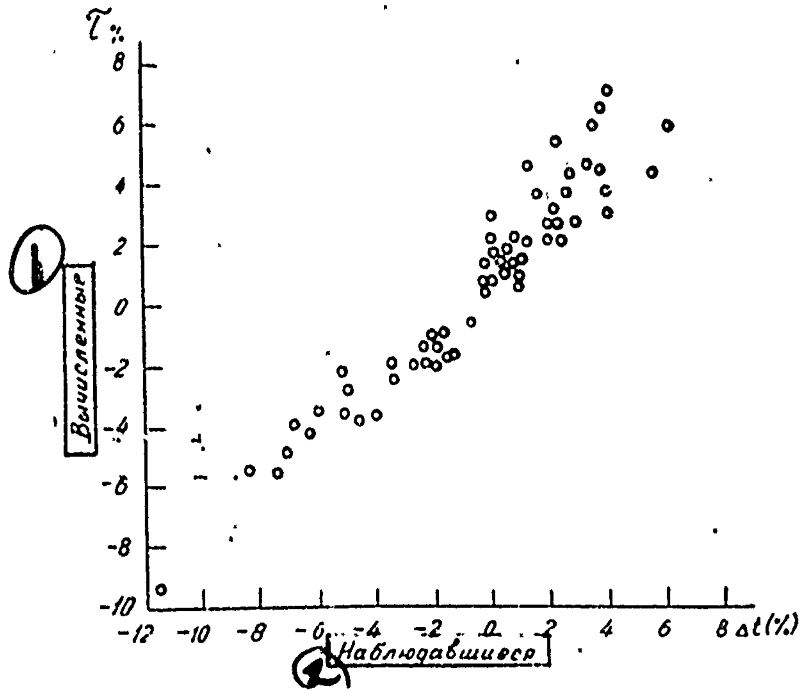


Figure 10. A graph comparing changes in the air temperature over a body of water as calculated by the nomogram $\eta\xi$ and actually observed.

For this, values of ζ for various distances and for the three wind velocity values 2, 5, and 10 m/sec were taken from the nomogram (Table 2).

Table 2

Change in the multiplier τ with an increase in the distance (L) and velocity of the wind (v), z = 150 cm.

Velocity (m/sec) / Distance (km)	2	5	10	Velocity (m/sec) / Distance (km)	2	5	10
	Magnitudes of T				Magnitudes of T		
1	0,22	0,10	0,0	12	0,40	0,37	0,33
2	0,31	0,21	0,10	14	0,40	0,37	0,34
3	0,33	0,27	0,10	16	0,41	0,38	0,35
4	0,35	0,30	0,22	18	0,42	0,38	0,35
5	0,36	0,32	0,24	20	0,42	0,39	0,37
6	0,37	0,33	0,26	25	0,43	0,40	0,37
7	0,37	0,34	0,28	30	0,44	0,40	0,38
8	0,38	0,35	0,30	35	0,46	0,41	0,39
9	0,38	0,36	0,31	40	0,47	0,41	0,39
10	0,39	0,37	0,32	50	0,48	0,42	0,40

From the data of the table it may be seen that, for example, the magnitude τ = 0.38 is reached with a wind velocity of 2 m/sec when the air has passed 8 km over the water, of 5 m/sec when it has travelled 16 km, and of 10 m/sec at 30 km.

Consequently, the applied theory shows that with an increase in the wind velocity, the effect of a body of water on the temperature of the lowest layers of air decreases. With low wind velocities, the air warms to a given temperature closer to the shore than with high wind velocities.

This contradicts the conslusion of S. I. Rudenko [18] that for identical distances (for instance, at Lake Constance) the air picks up the same quantity of water vapor regardless of the velocity of the wind. According to the data of Table 2, something

else ensues. For example, for a distance of 12 km with a wind velocity of 2 m/sec, $\underline{\tau}$ equals 0.40; for 5 m/sec, 0.37; and for 10 m/sec, only 0.33--ie, for high wind velocities at the same distance, a smaller increment takes place in the investigated factor, the temperature and humidity of the air.

It was said above that the empirical data regarding the effect of the wind velocity on the increment in the temperature and humidity of the air did not give a clear picture.[7]

According to the data calculated from the adopted theoretical formula, the magnitude $\underline{\tau}$ decreases with height above the level of the water. For the entire range of heights of 20-200 cm, the difference in the values of $\underline{\tau}$, ie, of $\Delta\underline{\tau}$, is equal to 0.22. For the range of heights of 150-200 cm, the change in $\underline{\tau}$ is equal to 0.06; for $\underline{z}$ from 50-150 cm it is also equal to 0.06; for the limit of $\underline{z}$ of 20-50 cm, it is equal to 0.10. With high wind velocities, and also in the first kilometers of the path, the difference in the values for various heights (z) decreases to half of those indicated.

From the data of the theoretical calculations it also follows that, with a change in the path of the air over the water from 0 to 50 km, the magnitude $\underline{\tau}$ changes from 0 to 0.48 (Table 2). And for the same distances, the empirical graph gives increment values of 0 to 60% (Appendix IV).

In conclusion, we give the calculation of the effect of a body of water on the temperature and humidity of the air under, for example, the following conditions: the temperature of the

surface of the body of water $\underline{T}$ = 0.0 degrees (melting ice); the temperature of the air on the land $\underline{t}$ = 5.2 degrees; the absolute humidity of the air on the land $\underline{e}$ = 7.2 millibars; the length of the path of the air over the body of water $\underline{L}$ = 28 km. The difference in the temperatures of the melting ice and the air (T-t) = 0.0-5.2 = -5.2 degrees; the deficit of humidity, calculated at the temperature of the ice, (E-e) = 6.1-7.2 = -1.1 millibars. Both differences here are negative. By Figures 7 and 8, or by the table (Appendix IV), we find that for $\underline{L}$ = 28 km the drop in the temperature of the air over the body of water should be 53% (coefficient $\underline{K}$ = 0.53) of -5.2, ie, equals -2.8 degrees; the decrease in the absolute humidity of the air over the body of water is given by the coefficient $\underline{K}_e$ = 0.94 (for $\underline{L}$ = 28 km), or 94% of -1.1 millibars equals -1.0 millibars. From here we obtain the temperature of the air, after its passage over the body of water, of 2.4 degrees, and the humidity of 6.2 millibars.

Thus, as a result of the investigations carried out at a number of resevoirs, the effect of a body of water on the temperature and humidity of the air above it in the period of the thawing and clearing of the ice, and also in the pre-ice period, was quantitatively established.

The properties found for the effect of a body of water were taken into account in the designs of a number of new resevoirs by a method of heat equilibrium in the periods of stable and clearing ice. Corrections were introduced into the calculations of heat

transfer by evaporation and through convection, appreciably (30-50%) lowering the values of these factors calculated by the usual formulas. It should be noted that, without the introduction of the specified corrections, errors of 4-5 to 10 days would have arisen in the computation of the periods of stable ice and the clearing of the resevoir in favor of their earlier onset.

The characteristics of the effect of a body of water on the temperature and humidity of the air over it obtained here may be used for the calculation and forecasting of these factors over bodies of water during investigations and calculations of heat exchange, evaporation, water temperature, etc.

Notes

[1]The results obtained from the data of the Kliazminsk observations showed that some deviation of the wind from the line of the two points of observation, with similar features of the shore, is not reflected in the readings of the temperature and humidity of the air.

[2]Information about the ice conditions, according to data from the Khoroshev and Primorsk stations, is cited in Appendix II.

[3]Data from the weather maps shows that in these instances there was no passing of fronts.

[4]A negative deficit in the humidity arises as a result of a low temperature of the ice or water with high magnitudes of the absolute humidity on the shore.

[5]Directly from the land to the point of observation Legkovo, the wind blows only at headings of SE and SSE. And even with a small deviation toward the E or S, the air stream, before passing over the land of the peninsula on which Legkovo is located, passes over small inlets. With all other headings, the wind, reaching Legkovo, will first travel a considerable distance over water.

[6]There was almost no snow in the periods of observation (Appendix III).

[7]Evidently, for a thorough determination of the effect of the wind velocity on the changes under natural conditions, it is necessary to organize in the field not only observations with psychrometers and anemometers, but also observations aimed at a detailed calculation of horizontal and vertical fluctuation in velocities (with an accuracy of up to 1 cm per sec.).

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Appendix I. Data from field observations at Tsimliansk Reservoir.

Year and Date	Time	Psychrometer at a height of 150 cm: Air temperature		Absolute humidity		Water temperature		Psychrometer at a height of 50 cm: Air temperature		Absolute humidity		Wind: Direction and velocity		Distance (km)
		Khoroshev	Primorsk	Khoroshev	Primorsk	Khoroshev	Primorsk	Khoroshev	Primorsk	Khoroshev	Primorsk	Khoroshev	Primorsk	
1959														
14.XI	13	1,3	2,4	4,0	2,2	6,3	6,0	2,2	2,4	4,9	1,7	ESE 3,8	E 8,3	33
	15	2,5	2,2	4,0	2,2	—	—	—	—	4,2	1,4	E 5,3	E 7,8	33
	17	1,9	−1,2	4,2	2,4	6,3	—	1,9	−1,2	4,8	2,4	E 9,8	E 3,5	33
	19	0,8	−3,2	4,4	2,1	6,2	5,9	1,2	−4,1	4,7	2,8	E 0,3	E 2,8	33
	21	0,4	—	4,6	—	—	—	0,6	−4,2	5,0	2,4	E 8,3	E 5,2	33
15.XI	7	−0,9	−6,4	4,1	3,1	5,8	5,5	—	−6,4	5,3	3,0	ESE 8,3	E 6,2	33
	8 30–9 00	−0,6	−2,5	[illegible]	3,2	5,8	—	−0,3	−2,4	5,5	3,0	E 7,8	E 6,2	33
	11	1,5	2,4	4,9	3,2	5,8	—	1,9	2,9	5,7	3,2	E 11,2	E 6,2	33
	13 00–13 30	2,7	4,4	4,5	3,1	6,0	5,4	2,8	3,0	5,4	3,5	E 7,4	E 6,9	33
	15	3,2	4,2	5,1	3,3	6,0	—	3,1	3,8	5,4	3,4	E 7,7	E 13,1	33
	17 00–17 30	3,0	0,6	5,3	3,2	6,0	5,7	3,0	0,6	5,4	3,2	E 7,9	E 6,8	33
	19	2,7	−1,4	5,2	3,3	5,5	5,2	2,6	−1,2	5,6	3,4	E 8,1	E 7,3	33
	21	2,4	−2,0	5,3	2,5	5,5	—	2,3	−2,2	5,6	2,8	E 9,4	E 7,0	33
16.XI	7	−0,1	−5,6	4,7	3,3	5,1	4,9	0,2	−5,6	5,2	3,2	E 5,4	E 4,3	33
	8 40	−0,2	−3,7	5,1	3,4	—	—	0,2	−3,3	5,4	3,7	—	E 4,6	33
	8 50	−0,3	−3,2	5,0	3,5	—	—	−0,1	−2,8	5,3	3,1	—	—	33
	9	−0,4	−2,8	5,0	3,7	—	—	0,0	−2,3	5,3	3,5	E 5,0	E 4,2	33
	11	1,1	2,4	5,0	3,6	—	—	1,4	3,0	5,2	3,3	E 5,5	E 5,8	33
	13 00–13 20	2,7	3,4	5,1	4,0	5,7	5,5	3,0	3,3	5,4	4,3	E 5,3	E 5,4	33
	15	2,9	2,6	4,9	4,0	—	—	2,5	3,5	5,0	3,9	E 6,4	E 4,9	33
	17	3,0	−0,2	4,8	3,6	—	—	3,0	−1,0	4,5	3,2	E 6,7	E 5,1	33
	17 10	2,9	−0,6	4,5	3,5	—	—	2,5	−1,0	4,9	3,2	—	—	33
	17 20	2,9	−0,2	4,6	3,6	—	—	2,5	−1,0	4,9	3,2	—	E 4,3	33
	19	1,9	−2,4	4,7	2,6	5,3	4,9	2,0	−2,6	5,2	2,8	E 7,3	E 4,2	33
	21	1,5	−4,4	4,8	3,1			1,8	−4,2	5,0	2,8	E 6,8	E 4,2	33
17.XI	7	−1,3	−6,0	4,6	3,2	4,7	4,4	−1,0	−6,1	5,0	3,5	E 8,0	E 7,8	33
	8 40–9 00	−1,4	−5,3	4,8	3,1	—	—	−0,9	−4,8	5,1	2,9	E 8,4	E 6,3	33
	11	−0,6	−0,9	4,5	3,6	—	—	−0,2	−0,4	5,1	3,4	E 8,4	E 7,3	33
	13 00–13 20	1,6	1,8	4,9	3,6	5,2	4,5	1,7	2,1	5,3	3,6	E 8,5	E 8,2	33
	15	1,9	1,6	5,1	3,5	—	—	1,9	1,8	5,3	3,4	E 8,3	E 7,6	33
	17 00–17 20	2,0	−0,3	4,8	3,4	—	—	1,6	−0,4	5,3	3,1	E 9,6	E 7,2	33
	19	1,1	−1,9	4,9	3,6	4,8	3,5	1,2	−1,8	5,3	3,2	E 10,6	E 7,6	33
	21	0,5	−2,8	5,1	3,6	—	—	0,5	−2,9	5,6	2,8	E 9,9	E 7,8	33
18.XI	7	−0,3	−3,4	4,9	3,4	4,2	3,8	0,0	−3,4	5,4	3,2	E 8,6	E 6,8	33
	8 40–9 00	0,1	−2,2	5,3	3,5	—	—	0,2	−1,6	6,0	3,4	E 10,1	E 8,5	33
	11	1,1	0,9	5,3	4,2	4,3	3,2	1,3	1,7	5,3	4,0	ESE 11,5	E 9,5	30
	13 00–13 20	2,4	3,8	5,4	3,5	—	—	2,2	4,0	5,7	3,8	ESE 9,4	E 10,0	30
	15	2,8	2,9	5,1	3,7	—	—	2,5	3,2	[illegible]	3,5	ESE 9,5	E 8,7	30
	17 00–17 20	2,2	−0,4	5,3	3,3	4,2	3,7	2,0	−0,4	5,0	3,6	ESE 9,9	E 5,6	30
	19	0,0	−2,4	5,2	3,8	—	—	−0,1	−2,4	5,1	3,6	ESE 8,0	E 6,5	30
	21	0,2	−2,2	5,5	3,8	2,9	3,5	−0,1	−2,4	5,4	3,8	ESE 8,4	E 8,1	30
19.XI	7	−1,8	−5,2	4,9	3,7	—	—	−2,0	−5,2	5,0	3,6	E 7,6	E 6,5	33
	8 40–9 00	−1,5	−3,8	5,0	3,9	—	—	−1,6	−3,5	4,8	3,7	E 8,2	E 7,6	33
	11	−0,8	−0,2	4,6	3,1	3,2	3,5	−1,2	0,1	4,4	3,5	E 7,9	E 8,1	33
	13 00–13 20	0,1	0,9	4,5	3,2	—	—	0,0	1,3	4,4	3,3	E 7,2	E 7,6	33
	15	0,1	0,0	4,6	2,6	—	—	0,1	0,1	4,5	3,3	E 6,7	E 5,6	33
	17 00–17 20	−0,3	−2,0	4,7	3,5	—	—	−0,2	−2,0	4,7	3,7	E 7,7	E 6,6	33
	19	−0,6	−2,9	4,7	3,6	3,0	2,2	−0,6	−2,9	4,9	3,4	E 7,0	E 7,4	33

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Appendix I. Data from field observations at Tsimliansk Reservoir.

Year and Date	Time	Psychrometer at a height of 150 cm						Psychrometer at a height of 50 cm				Wind		Distance (km)
		Air temperature		Absolute humidity		Water temperature		Air temperature		Absolute humidity		Direction and velocity		
		Khoroshev	Primorsk	Khoroshev	Primorsk	Khoroshev	Primorsk	Khoroshev	Primorsk	Khoroshev	Primorsk	Khoroshev	Primorsk	
1953 4.IV	7	−1,9	−1,6	4,0	5,0	—	0,7	−1,7	−1,2	4,4	—	ENE 4,0	ENE 10,5	40
	13	1,6	2,6	5,1	5,2	—	0,7	2,2	3,9	5,4	5,2	ENE 10,5	ENE 8,7	40
	19	1,2	0,9	8,2	5,6	—	1,4	1,3	1,1	6,2	5,5	ENE 7,3	ENE 7,6	33
5.IV	7	1,6	0,4	5,7	5,2	—	1,1	1,7	0,5	6,0	—	ENE 5,1	ENE 7,1	40
	13	2,6	8,4	5,5	5,3	—	1,5	2,1	8,2	5,9	5,9	E 3,7	ENE 10,5	36
	15	2,8	8,1	5,5	5,0	—		3,4	7,9	5,9	5,6	E 6	E 8,6	31
	17	2,6	5,5	5,6	5,1	—	—	2,7	6,0	—	—		—	—
	19	2,6	2,6	5,7	5,4	—	1,9	2,7	2,5	6,0	6,4	ENE 8,1	NE 4,8	33
6.IV	7	0,4	9,3	4,8	5,7	0,1	1,1	0,7	−1,2	4,9	5,5	NE 4,9	ENE 6,7	33
	13	4,1	11,8	5,8	5,4	—	1,3	4,9	12,4	6,3	5,3	ENE 4,9	ESE 7,0	32
	19	4,8	2,0	6,7	6,5	—	2,1	4,7	3,2	6,8	6,4	NE 6,9	NE 3,1	26
7.IV	7	−0,1	−0,6	5,1	5,7	—	0,8	0,7	−0,6	—	—	NNE 4,1	NE 4,7	
	13	5,5	3,2	5,0	6,8	—	1,3	5,9	3,0	—	—	ENE 2,7	NNE 5,8	15
	19	5,7	2,1	6,6	6,6	—	1,9	5,6	2,1	6,7	6,5	NE 5,1	NE 4,4	26
8.IV	7	1,5	−0,3	5,7	5,6	—	0,9	2,3	0,0	5,9	5,6	NNE 2,2	NNE 2,1	—
9.IV	13	4,5	6,2	6,8	6,0	—	—	5,0	7,4	7,3	6,1	ENE 1,4	NE 3,1	35
10.IV	7	7,2	7,9	7,7	8,3	—	2,6	7,2	8,3	8,0	9,4	W 1,6	SSE 4,9	(12)
	13	5,8	20,2	8,0	7,6	—	2,8	8,7	21,4	8,2	6,6	ENE 1,8	SSE 4,3	(30)
	19	10,0	13,3	6,6	9,0	—	3,0	9,3	12,8	6,7	8,5	ESE 3,7	SE 3,3	22
11.IV	7	4,5	7,7	6,6	7,5	—	2,8	4,3	8,0	6,7	7,6	S 2,7	SE 8,2	18
	9	4,2	10,3	6,5	8,0	—		3,5	12,5	6,4	8,1	S 2,7	SSE 7,2	18
	13	9,0	17,2	7,0	8,1	—	2,6	6,6	18,2	6,9	8,2	SSW 0,5	SSE 4,4	18
	19	12,1	7,7	10,9	7,0	0,1	2,3	11,5	7,1	10,8	7,2	WSW 0,9	ENE 2,2	—
12.IV	7	0,9	1,4	6,0	5,9	0,5	0,8	1,0	2,4	6,2	5,7	N 8,4	WNW 6,8	29
	11	5,0	3,7	5,1	5,4	—	—	5,2	—	—	—	NNW 8,7	NNW 6,3	25
	13	6,3	3,9	4,4	5,6	—	0,9	6,6	5,2	4,7	5,5	NNW 9,1	NNW 5,6	26
	15	6,7	2,7	4,6	6,0	—	—	7,0	4,5	4,8	5,6	NNW 9,0	NW 5,4	24
	17	5,3	3,6	4,7	5,5	—	—	5,5	4,7	4,7	5,5	NNW 8,8	NW 6,1	24
	19	3,1	2,0	5,2	5,5	2,5	1,0	3,2	2,1	5,2	5,4	NNW 5,5	NW 4,9	24
13.IV	7	1,6	0,6	4,8	5,3	1,7	0,4	1,7	1,3	5,1	5,1	W 5,8	WSW 5,5	20
	13	5,6	3,2	4,8	5,4	2,5	0,6	6,2	3,1	4,8	5,9	WNW 5,8	WSW 3,1	22
	19	2,3	1,5	5,3	5,8	1,9	0,9	2,8	2,0	5,5	5,8	W 0	NNW 0,3	25
14.IV	7	2,3	5,0	6,3	6,7	1,8	0,5	2,5	5,3	6,4	7,1	SE 1,0	SSE 5,9	16
	9	3,0	7,8	6,9	6,2	—	0,7	3,0	9,3	6,9	7,0	SE 4,6	SSE 7,9	18
	11	3,8	10,5	6,8	6,6	—	0,8	3,6	11,7	6,8	6,9	SSE 2,9	SSE 8,7	18
	13	4,1	9,8	7,0	6,8	2,0	1,0	4,2	10,9	7,1	7,6	S 1,2	SSE 5,6	18
	15	5,4	9,7	6,9	7,1	—	1,2	5,4	10,2	7,0	7,3	SE 2,0	SSE 5,9	18
	17	4,2	9,2	7,0	7,8	—	1,4	3,8	9,2	7,1	7,3	SE 1,5	SSE 4,8	18
	19	4,3	8,5	7,1	7,8	2,1	1,6	4,7	8,4	7,2	8,0	SE 2,0	SSE 3,0	18
15.IV	7	6,0	4,6	6,5	7,5	1,9	1,5	5,9	4,9	6,8	7,4	SW 0,8	WSW 6,8	—
	13	10,5	6,0	6,3	7,4	2,7	—	10,7	7,1	6,7	7,4	NW 2,6	NW 2,6	—
	15	10,7	5,3	6,5	6,6	—	—	10,8	5,4	6,6	6,9	NW 2,4	WNW 3,1	23
	17	9,7	5,2	6,1	6,8	—	—	9,6	5,3	6,9	6,8	NW 2,1	WNW 3,1	23
	19	8,5	5,2	7,4	6,5	2,5	2,0	8,6	5,2	7,3	6,8	WNW 1,9	WNW 3,0	23
16.IV	7	7,2	2,5	6,6	6,3	2,2	1,9	7,6	2,5	6,6	6,5	NNE 2,9	0	(15)
	13	11,5	6,9	7,9	7,6	2,9	2,2	12,4	7,0	8,1	7,6	E 3,2	NNE 7,1	(21)
18.IV	7	8,2	9,9	6,9	8,3	3,8	3,0	9,1	10,5	7,2	8,0	NE 4,8	ESE 4,4	30
	13	10,5	22,9	7,2	6,6	4,2	3,6	10,1	23,7	7,3	7,2	ESE 3,4	ESE 11,7	25
	19	10,5	17,8	—	—	3,5	4,5	10,2	17,7	6,7	8,0	ESE 7,9	ESE 10,5	25
19.IV	7	7,5	12,7	7,0	6,8	3,2	5,2	7,0	12,9	7,3	6,8	ESE 6,4	ESE 8,7	25
	13	11,6	13,5	7,1	4,0	—	6,2	11,1	17,5	7,5	5,4	ESE 7,4	SE 11,5	22

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Appendix I. Data from field observations at Tsimliansk Reservoir.

Year and Date	Time	Psychrometer at a height of 150 cm: Air temperature: Khoroshev	Air temperature: Primorsk	Absolute humidity: Khoroshev	Absolute humidity: Primorsk	Water temperature: Khoroshev	Water temperature: Primorsk	Psychrometer at a height of 50 cm: Air temperature: Khoroshev	Air temperature: Primorsk	Absolute humidity: Khoroshev	Absolute humidity: Primorsk	Wind: Direction and velocity: Khoroshev	Direction and velocity: Primorsk	Distance (km)
1952														
5.XII	7	−10.8	−7.4	2.2	3.2	0.2	0.8	−10.9	−7.1	2.2	3.4	NW 5.2	NNW 9.6	24
	8 30–8 40	−9.8	−7.3	2.4	2.9	—	—	−9.8	−6.9	2.3	3.2	NW 5.4	NNW 2.3	24
	8 50–9 00	−9.6	−6.7	2.4	3.5	—	—	−9.6	−6.7	2.3	3.3	NW 5.4	NNW —	24
	11	−6.9	−6.2	2.5	2.9	—	—	−6.7	−5.9	2.4	3.4	NW [illegible]	NNW 7.4	24
	13 00–13 20	−6.0	−5.7	2.4	3.2	0.7	1.0	−5.5	−4.9	2.4	3.5	NW 2.6	NNW 7.5	24
	15	−5.8	−5.2	2.7	3.1	—	—	−5.4	−4.1	2.3	2.8	NW 2.8	NNW 4.2	24
	17 00–17 20	−7.5	−5.3	2.7	3.3	—	—	−7.9	−4.4	2.7	3.3	NW [illegible]	NW 5.0	23
	19	−9.0	−6.0	1.6	3.1	0.3	0.5	−9.2	−5.0	1.6	3.2	WNW 2.6	NW 6.1	23
10.XII	7	−14.2	−7.8	1.7	3.0	0.1	—	−14.8	−7.1	1.6	3.5	NW 4.0	NNW 7.4	24
	8 30–8 50	−14.6	−8.2	1.6	2.7	—	—	−14.5	−5.9	1.5	2.9	NW 5.3	NNW 9.8	24
	11	−12.6	−10.2	1.7	2.3	—	—	−12.7	−9.6	1.7	2.6	NW 7.1	NNW 7.3	24
	13 00–13 20	−11.5	−9.9	2.1	2.2	0.2	—	−11.5	−9.4	1.8	2.5	NNW 8.8	NW 9.0	24
	15	−11.2	−9.4	1.9	2.1	—	—	−11.1	−9.1	1.8	2.2	NNW 7.7	NW 10.4	24
	17 00–17 20	−14.2	−10.4	1.6	2.2	—	—	−14.1	−10.1	1.6	2.3	NW 6.8	NW 8.8	23
	19	−15.1	−11.0	1.5	1.7	0.1	—	−15.0	−11.3	1.5	1.9	NW 5.8	NW 5.9	23
	21	−16.6	−12.2	1.4	2.2	—	—	−16.5	−12.3	1.5	2.2	WNW 4.5	NW 5.5	23
12 XII	13 00–13 20	−5.0	−5.2	2.5	2.4	0.3	—	−5.8	−4.9	2.6	2.3	SSE 1.9	SE 3.9	18
	15	−5.4	−5.5	2.7	2.7	—	—	−5.1	−5.6	2.5	2.7	ESE 2.1	SE 1.2	22
	17 00	−4.8	−8.2	3.4	2.6	—	—	−4.5	−8.6	3.3	2.7	ESE 1.6	ESE 1.8	23
	17 10	−4.7	−8.5	3.4	2.5	—	—	−4.5	−8.6	3.3	2.8	ESE 1.6	ESE 1.4	25
	17 20	−4.8	−9.5	3.4	2.5	—	—	−4.6	−10.0	3.4	2.5	ESE 1.6	ESE 0.9	23
	19	−5.4	−9.2	3.4	2.6	0.2	—	−5.3	−9.3	3.2	−2.6	ESE 3.8	ESE 2.3	23
	21	−5.2	−8.0	3.6	2.4	—	—	−5.0	−8.1	3.4	2.7	SE 6.7	ESE 1.4	22
13 XII	7	−3.1	−2.2	4.9	5.1	0.4	0.5	−3.2	−2.4	4.7	5.1	ESE 3.0	ESE 3.0	25
1953														
27.III	19	0.7	2.2	5.3	5.4	—	0.3	0.8	1.3	5.4	5.5	SSW 1.3	SSE 6.6	13
28.III	7	1.0	0.8	6.2	5.7	0.0	0.5	1.0	1.0	—	—	SW 1.3	SE 8.9	
29.III	7	1.1	1.0	6.1	6.1	0.1	0.4	1.1	1.0	6.3	6.2	NW 6.5	NW 6.4	23
	13	3.3	1.3	6.1	6.3	—	—	3.0	3.2	6.4	5.9	NW 4.1	NW 4.9	23
30.III	7	−1.6	−2.6	4.3	4.6	0.0	—	−1.9	−2.6	—	—	WSW 3.2	WSW 3.2	13
	13	4.4	2.4	6.1	5.3	—	—	4.1	3.6	6.2	6.0	WSW 4.0	WSW 2.0	13
31.III	7	1.2	1.6	5.7	5.7	—	—	1.3	1.6	6.0	5.8	SW 1.1	SSW 3.1	12
	13	8.7	8.1	5.9	7.2	—	0.7	8.8	9.9	6.6	6.7	SW 1.8	SSW 9.0	12
	19	3.4	4.3	5.9	6.6	—	—	3.2	4.1	6.2	6.4	ESE 3.5	ESE 1.4	25
1.IV	7	−0.2	1.1	5.4	5.9	—	0.7	0.5	1.3	5.8	5.6	E 2.1	ENE 6.8	36
	9	0.9	2.6	6.0	6.2	—	—	1.5	2.9	6.3	6.0	ESE 3.4	E 5.0	30
	11	2.8	4.6	6.6	6.7	—	—	4.5	3.9	7.4	6.6	ESE 3.2	E 5.9	30
	13	3.0	7.8	6.7	7.7	—	0.8	4.6	5.2	7.3	7.9	E 3.5	E 6.7	33
	15	3.8	7.5	6.7	7.3	—	—	5.1	8.3	7.3	8.7	E 3.5	ENE 9.0	36
	17	2.9	6.2	6.6	5.8	—	—	3.0	7.2	6.9	8.0	E 4.8	E 6.7	33
	19	2.5	2.2	6.8	6.6	—	1.2	2.6	2.2	6.8	6.9	E 4.9	ESE 2.0	30
2.IV	7	1.5	2.8	6.3	6.6	—	—	1.8	2.8	6.4	6.7	E 3.5	E 4.0	33
	9	2.8	6.0	6.4	7.2	—	—	3.7	7.1	7.2	7.3	E 9.0	E 6.9	33
	11	4.9	8.7	7.0	7.8	—	—	5.9	9.4	7.6	8.9	E 5.8	E 7.3	33
	13	5.0	13.3	6.9	8.6	—	1.0	6.1	13.7	6.8	8.8	ENE 6.7	E 9.9	36
	19	5.4	2.2	7.3	6.6	—	1.4	5.1	2.4	7.5	6.7	NE 9.0	NE 8.6	25
3.IV	7	1.1	0.6	5.7	5.9	—	1.1	1.2	0.6	5.9	5.9	NE 9.1	NE 11.5	25
	13	3.4	4.4	6.1	7.0	—	1.2	3.7	5.3	6.4	5.1	E 7.4	NE 8.7	35
	19	1.6	2.0	5.7	6.2	—	1.4	1.7	1.5	6.0	6.3	ENE 9.6	NE 13.6	35

Appendix I. Data from field observations at Tsimliansk Reservoir.

Year and Date	Time	Psychrometer at a height of 150 cm: Air temperature: Khoroshev	Air temperature: Primorsk	Absolute humidity: Khoroshev	Absolute humidity: Primorsk	Water temperature: Khoroshev	Water temperature: Primorsk	Psychrometer at a height of 50 cm: Air temperature: Khoroshev	Air temperature: Primorsk	Absolute humidity: Khoroshev	Absolute humidity: Primorsk	Wind: Direction and velocity: Khoroshev	Direction and velocity: Primorsk	Distance (km)
1952														
28.XI	7	2,2	2,8	6,8	7,0	0,6	—	2,0	2,8	6,7	6,9	ESE 4,3	SE 3,4	22
	13	2,3	4,2	6,9	7,5	0,8	2,2	2,1	4,2	6,9	7,5	ESE 4,1	SE 7,9	22
29.XI	7	1,5	1,4	6,7	6,6	0,8	2,0	1,4	1,4	6,5	6,4	SE .9	SE 6,4	19
	11	1,5	2,2	6,5	6,7	—	—	1,4	2,6	6,4	6,8	SE 8,3	SE 8,5	19
	13 00—13 20	1,7	1,8	6,6	6,3	0,9	2,2	1,6	1,9	6,4	6,3	SE 9,2	SE 8,0	19
	15	1,5	1,5	6,5	6,2	—	—	1,4	1,6	6,4	6,3	ESE 7,9	SE 8,6	22
	17 00—17 20	1,0	0,7	6,1	5,8	—	—	0,9	0,8	6,1	5,7	ESE 13,3	ESE 9,8	25
	19	0,7	0,2	5,7	5,1	0,8	2,2	0,6	0,1	5,8	5,2	ESE 9,3	ESE 9,0	25
	21	0,5	−0,8	5,3	5,0	—	—	0,4	−0,6	5,4	4,6	ESE 13,3	ESE 10,1	25
30.XI	7	−0,5	−1,4	5,3	4,8	0,5	1,5	−0,5	−1,4	5,3	5,1	ESE 11,4	SE 9,4	22
	8 40—9 00	−0,1	−1,0	5,5	5,2	—	—	0,0	−0,9	5,4	5,2	ESE 12,3	SE 9,6	22
	13	0,4	0,8	6,1	6,3	0,5	1,5	0,4	0,7	6,0	6,1	ESE 10,4	SE 8,3	22
	21	1,2	0,6	6,6	6,2	—	—	1,2	0,6	6,4	6,0	SE —	SE 8,8	19
1.XII	7	2,3	2,1	6,6	7,0	0,8	1,7	2,2	2,1	6,7	6,9	WSW 0,1	S 3,2	
	19	0,9	−0,2	6,3	5,8	0,8	1,6	0,9	0,0	6,2	5,9	SE 6,7	SE 5,0	19
	21	0,3	−0,9	5,9	5,6	—	—	0,2	−0,6	6,0	5,5	SE 6,7	SE 5,0	19
2.XII	7	−0,5	−1,9	5,6	5,1	0,8	1,4	−0,4	−1,8	6,7	4,9	SE 6,0	SE 8,7	19
	13 00—13 20	1,1	0,8	6,3	6,1	0,8	1,4	1,0	0,9	6,1	6,1	SSE 4,7	SE 9,0	18
	19	2,2	2,4	6,6	5,8	0,8	1,5	2,1	2,4	6,5	6,7	S 4,2	SSE 3,5	18
3.XII	13	0,5	1,6	6,2	6,7	0,8	1,8	—	1,6	—	6,7	NNE 4,2	NNE 6,2	23
4.XII	7	5,3	6,2	8,5	9,1	1,5	1,8	5,3	6,3	8,5	9,0	SSW 5,1	S 9,0	18
	13	4,2	5,2	7,6	8,0	2,2	1,8	4,2	5,1	7,6	8,0	W 4,6	WSW 6,0	
	15	2,5	2,4	6,8	6,8	1,9	—	2,4	2,6	6,9	6,6	W 3,5	W 5,3	27
	17 00—17 20	1,7	2,2	6,3	6,5	—	—	1,7	2,2	6,3	6,6	W 2,9	W 4,7	27
	19	1,5	2,2	6,2	6,5	1,8	2,0	1,5	2,3	6,2	6,4	W 3,0	W 3,5	27
	21	0,1	1,2	5,5	6,2	—	—	0,1	1,4	5,8	6,2	WNW 2,3	W 2,5	25
5.XII	7	1,3	4,2	6,6	7,8	1,8	2,0	1,1	4,1	6,5	8,2	ENE 2,3	ESE 1,7	32
	13	1,3	1,4	5,4	6,6	1,8	2,3	1,3	1,6	6,4	6,4	NNW 8,4	NW 8,7	26
	19	−3,1	−1,6	4,1	4,9	1,4	1,7	−3,0	−1,9	3,9	7,0	NNW 6,3	NNW 11,9	26
	21	−4,0	−2,4	3,7	4,4	—	—	−3,9	−2,2	3,6	4,6	NNW 6,3	N 3,5	28
6.XII	7	−7,2	−3,0	3,1	3,5	1,2	1,5	−7,1	−4,6	6,5	4,0	WNW 3,5	NW 4,6	23
	15	−3,1	−2,0	3,0	3,7	—	—	−3,1	−1,8	3,0	3,7	NW 5,3	NNW 9,2	24
	17 00—17 20	−5,4	−3,1	3,1	3,6	—	—	−5,5	−2,8	3,1	3,8	NW 2,7	NNW 5,0	24
	19	−6,5	−3,4	3,0	3,6	0,7	0,9	−6,5	−3,3	2,9	3,5	NW 2,1	N 4,8	25
	21	−6,7	−3,9	2,9	3,6	—	—	−6,9	−3,8	3,0	3,3	NW 1,9	N 2,8	26
7.XII	7	−4,6	−6,6	3,5	3,1	0,2	1,2	−4,4	−6,6	3,6	3,1	SE 3,9	SE 4,1	19
	8 40—9 00	−3,9	−5,9	3,6	3,4	0,2	—	−3,8	−5,7	3,9	3,3	SE 6,6	SE 5,2	19
	11	−3,4	−4,5	3,7	3,2	—	—	−3,2	−4,2	3,9	3,6	SE 5,9	SE 4,9	19
	13 00—13 20	−2,5	−3,3	4,2	3,9	0,1	1,2	−2,3	−3,1	4,4	4,2	SE 7,3	SE 5,5	19
	15	−1,9	−2,6	4,7	4,5	—	—	−1,8	−2,6	4,3	4,4	SE 6,9	SE 5,7	19
	17 00—17 20	−1,2	−2,0	5,1	4,6	—	—	−1,1	−2,0	5,1	4,8	ESE 4,9	ESE 4,6	25
	19	−0,7	−1,2	5,4	5,3	0,1	1,0	−0,6	−1,4	5,4	5,3	ESE 3,6	ESE 1,3	25
	21	−0,7	−0,8	5,4	5,7	—	—	−0,5	−0,3	5,5	6,0	— 0,0	—	

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Appendix I. Data from field observations at Tsimliansk Reservoir.

Year and Date	Time	Psychrometer at a height of 150 cm: Air temperature, Khoroshev	Air temperature, Primorsk	Absolute humidity, Khoroshev	Absolute humidity, Primorsk	Water temperature, Khoroshev	Water temperature, Primorsk	Psychrometer at a height of 50 cm: Air temperature, Khoroshev	Air temperature, Primorsk	Absolute humidity, Khoroshev	Absolute humidity, Primorsk	Wind: Direction and velocity, Khoroshev	Direction and velocity, Primorsk	Distance (km)
1952														
20.XI	7	−1,5	−4,1	4,6	3,1	2,4	2,6	−1,5	−4,0	4,6	3,2	E 6,5	E 3,2	33
	8 40—9 00	−1,3	−3,5	4,6	3,5	—	—	−1,4	−3,4	4,7	3,4	E 7,2	E 3,7	33
	11	−1,3	−2,4	4,7	3,8	—	—	−1,3	−2,2	4,8	3,5	E 6,0	E 6,2	33
	13 00—13 20	−1,1	−2,0	4,8	4,1	2,4	2,4	−0,8	−1,9	5,0	3,9	E 5,6	E 6,0	33
	15	−0,9	−1,5	5,0	4,2	—	—	−0,8	−1,4	5,2	4,0	E 6,0	E 5,9	33
	17 00—17 20	−0,5	−1,3	4,7	3,8	—	—	−0,2	−1,6	5,1	3,7	E [illegible]	E 5,5	33
	19	−0,9	−0,8	4,6	4,3	2,2	2,3	−0,5	−0,8	4,6	4,3	E 4,6	E 6,4	33
	21	−0,3	−1,1	4,9	3,7	—	—	−0,2	−1,1	5,1	3,6	E 5,1	E 3,4	33
21.XI	7	−2,1	−5,5	3,0	3,1	2,8	2,0	−1,6	−5,8	4,7	3,1	ESE 4,1	E 4,2	38
	8 40—9 00	−2,4	−5,1	4,0	3,0	—	—	−1,9	−4,7	4,4	3,0	ESE 3,3	ESE 3,4	33
	11	−1,3	0,4	4,0	2,9	—	—	−0,7	0,7	4,3	3,1	E 2,3	ESE 3,9	30
	13 00—13 20	−0,3	0,9	4,0	3,0	3,2	2,5	0,0	1,2	4,3	3,0	NE 2,4	ENE 3,0	40
22.XI	13	−2,4	−2,0	4,0	3,9	3,5	2,3	−2,1	−1,5	4,4	3,7	ENE 3,5	ENE 5,0	33
	19	−1,0	−5,0	5,1	3,1	3,1	2,6	−1,0	−5,2	5,2	3,3	E 5,8	ENE 4,7	36
	21	−1,3	−6,0	4,5	3,6	—	—	−1,1	−6,1	4,7	3,1	E 7,7	ENE 6,0	36
23.XI	7	−2,0	−6,0	4,3	3,0	2,2	3,2	−1,4	−6,0	4,7	3,0	ESE 8,1	ESE 8,1	33
	9	−1,7	−3,7	4,2	3,1	—	—	−1,2	−3,6	4,6	3,3	ESE 10,9	ESE 8,3	33
	11	−0,7	−1,4	4,3	3,3	—	—	−0,6	−1,1	5,0	3,2	E 11,2	ESE 9,6	30
	13 00—13 20	0,3	−0,2	4,4	3,3	1,8	2,3	0,2	0,2	4,7	3,3	E 9,9	ESE 9,2	30
	15	0,7	0,6	4,2	3,0	—	—	0,4	0,7	4,5	3,1	ESE 11,6	E 9,5	30
	17	0,3	−2,1	4,2	2,8	—	—	0,4	−2,3	4,5	3,8	ESE 9,8	E 7,9	30
	17 10	0,0	−2,1	4,3	2,8	—	—	−0,1	−2,3	4,4	2,8	—	—	30
	17 20	0,2	−2,2	4,5	2,9	—	—	0,2	−2,2	4,5	3,7	—	E [illegible]	30
24.XI	7	−1,5	−3,3	4,6	3,6	0,7	1,7	−1,4	−2,2	4,6	2,9	ESE 11,5	E 8,7	30
	8 40—9 00	−1,5	−2,8	4,7	4,2	—	—	−1,3	−2,7	4,8	4,0	ESE 11,7	E 8,8	30
	11	−0,3	−1,0	5,1	4,5	—	—	−0,6	−0,9	5,1	4,4	ESE 11,8	E 9,1	30
	13	0,3	0,2	5,4	5,1	0,6	2,0	0,1	0,4	5,4	5,0	ESE 9,5	E 8,7	30
	13 10	0,1	0,2	5,4	5,1	—	—	0,0	0,2	5,4	5,2			
	13 20	0,1	−0,4	5,5	5,2	—	—	0,1	−0,4	5,5	5,3		E 7,8	
	15	[illegible]	0,9	5,9	5,6	—	—	0,5	0,9	5,9	5,7	ESE 9,5	E 8,9	30
	17 00—17 20	1,1	1,4	6,1	5,8	—	—	1,0	1,4	6,1	5,8	E 8,5	E 9,2	33
	19	1,3	1,6	6,1	5,4	0,6	1,3	1,3	1,3	5,9	5,2	E 9,2	E 9,6	33
	21	1,5	1,8	6,0	5,1	—	—	1,4	1,8	6,0	5,2	E 8,5	E 9,5	33
25.XI	7	−1,1	−2,6	5,0	4,3	0,5	1,8	−1,1	−2,2	5,1	3,9	E 8,7	E 7,0	33
	8 40—9 00	−1,1	−2,5	5,2	4,3	—	—	−1,0	−2,4	5,3	4,2	ESE 9,4	E 9,0	30
	11	−0,9	−1,9	5,2	4,5	—	—	−0,8	−1,8	5,3	4,4	ESE 10,2	E 8,3	30
	13 00—13 20	−0,5	−1,8	5,3	4,6	0,3	1,7	−0,7	−1,7	5,4	4,6	ESE 10,5	ESE 8,7	25
26.XI	13	2,2	2,9	7,0	7,4	0,6	2,2	2,0	3,2	7,0	7,3	SE 2,5	SSE 2,9	18
	19	2,0	4,0	7,0	7,9	4,5	2,0	1,9	3,6	7,0	7,7	SE 2,2	SE 3,9	19
	21	2,1	3,9	7,1	7,9	—	—	1,9	3,6	6,9	7,5	SE 2,3	SE 4,3	19
27.XI	7	2,1	2,8	6,9	7,3	—	—	1,8	2,8	6,8	7,1	SE 8,2	SE 9,1	19
	8 40—9 00	2,3	4,1	7,1	7,8	—	—	2,0	4,1	6,9	7,4	SE 9,4	SE 11,7	19
	11	2,9	4,7	7,3	7,7	—	—	2,6	4,7	7,0	7,8	SE 7,6	SE 9,8	19
	13 00—13 20	2,8	5,0	6,9	7,7	0,6	2,2	2,4	5,1	6,9	7,8	SE 5,6	SE 9,1	19
	15	3,3	5,0	6,9	7,6	—	—	2,7	4,9	6,8	7,7	SE 4,2	SE 6,6	19
	17 00—17 20	2,4	4,0	6,8	7,2	—	2,2	2,2	4,0	6,8	7,3	ESE 4,1	SE 7,1	18
	19	2,5	3,1	6,8	6,8	0,6	2,2	2,3	3,2	6,8	6,8	ESE 4,6	SE 9,6	22
	21	2,3	2,4	6,6	6,3	—	—	2,0	2,4	6,6	6,2	ESE 4,8	SE 9,4	22

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Дата	Часы	Психрометр на высоте 200 см: Температура воздуха, Цимлянская	Психрометр на высоте 200 см: Температура воздуха, Приморский	Психрометр на высоте 200 см: Абсолютная влажность, Цимлянская	Психрометр на высоте 200 см: Абсолютная влажность, Приморский	Температура воды: Цимлянская	Температура воды: Приморский	Психрометр на высоте 50 см: Температура воздуха, Цимлянская	Психрометр на высоте 50 см: Температура воздуха, Приморский	Психрометр на высоте 50 см: Абсолютная влажность, Цимлянская	Психрометр на высоте 50 см: Абсолютная влажность, Приморский	Направление и скорость ветра: Цимлянская, 200 см	Направление и скорость ветра: Цимлянская, 50 см	Направление и скорость ветра: Приморский, 200 см	Направление и скорость ветра: Приморский, 50 см	Расстояние
1954 г.																
10.IV	7	5,2	1,1	7,2	6,5	2,0	—	4,2	1,2	7,2	6,7	N 6,5	4,6	N 1,1	0,8	28
10.IV	13	6,9	4,9	7,4	7,3	—	—	5,6	5,3	7,3	7,5	N 6,5	1,5	N 1,4	1,0	28
10.IV	19	6,9	2,6	6,1	6,3	2,0	—	6,1	2,3	6,3	6,6	N 4,2	2,8	NW 3,5	2,9	22
11.IV	13	3,1	2,0	6,6	5,9	—	—	3,1	2,1	6,8	6,1	NNW 3,9	2,5	NE 1,1	0,6	33
12.IV	7	−1,4	−0,6	5,5	5,4	1,5	0,2	−0,9	−0,7	5,2	5,5	N 2,7	2,3	NE 5,2	4,6	33
14.IV	7	6,8	4,2	9,4	8,2	2,3	0,5	6,1	4,2	9,3	8,1	N 2,8	2,3	0	0	—
14.IV	19	9,3	5,6	10,8	9,1	2,3	0,4	9,1	5,5	10,8	8,9	NNW 4,4	3,1	W 2,9	1,9	22
15.IV	7	4,2	3,6	8,2	7,9	2,2	—	4,2	3,1	8,2	7,6	WNW 1,6	1,1	W 3,0	2,5	22
15.IV	13	5,5	9,4	8,9	9,4	—	—	4,2	10,2	8,2	11,3	ESE 1,9	0,7	0,9	0,9	17
15.IV	19	8,2	10,9	5,5	7,5	2,0	0,9	5,9	9,5	6,4	9,2	ESE 1,4	0,7	S 1,1	1,0	17
22.IV	13	14,4	9,3	7,0	8,8	—	—	12,2	8,3	7,1	10,2	WSW 3,0	2,3	NNW 3,1	1,4	27
22.IV	19	10,9	12,0	7,4	7,4	5,0	2,9	10,5	11,7	7,1	7,6	ENE 3,8	3,2	E 5,1	3,0	53
23.IV	7	7,4	9,8	9,1	9,4	4,4	2,3	6,7	9,6	8,9	9,6	SSE 3,2	2,5	ESE 7,3	7,2	10
23.IV	13	9,8	11,5	10,5	11,4	—	—	8,8	11,5	10,1	11,2	SSE 4,0	3,4	SSE 6,3	3,4	—
24.IV	7	2,4	2,2	5,4	5,9	4,2	2,8	2,7	2,0	5,3	5,8	NNW 5,5	4,7	NNW 9,7	9,3	27
25.IV	7	4,7	4,8	6,0	5,6	4,7	3,5	4,4	5,0	6,1	5,4	E 7,6	6,6	SE 5,3	2,9	30
25.IV	13	7,6	13,2	7,1	5,8	—	—	7,4	13,5	7,2	5,5	SSE 3,7	3,0	SE 8,0	8,1	10
28.IV	7	6,8	9,4	8,0	6,8	7,9	5,5	6,7	9,3	8,2	6,4	SSE 1,5	1,5	SSW 4,8	3,4	10
28.IV	13	10,8	16,3	7,3	7,2	—	—	9,8	19,7	8,1	5,9	SE 3,2	1,5	S 4,3	5,4	13
29.IV	13	9,0	6,6	6,5	7,6	8,8	6,2	9,5	6,5	6,7	7,4	N 6,7	5,5	NNW 4,8	4,3	27

Appendix II

Ice Conditions at Tsimliansk Resevoir
in the Spring of 1953

From the data of observations at Khoroshev (western shore).

March 27-April 8. Stable ice. Melted water on the ice at the shore. Fissures. Shifts (the resevoir is under ice, the temperature of its surface should be considered zero).

April 9. A strip of water of a width of about 70 m. is noticed at the shore.

April 10. Stable ice.

April 11. Stable ice.

April 12-14. The resevoir opened. Ice floated and gradually disappeared near the center of the body of water and at the side at the opposite bank (the resevoir has almost cleared itself of ice).

April 15. The ice has disappeared. Completely.

From the data of observations at Primorsk (southeastern shore).

To March 20. Stable ice. Snow on the ice melts in the afternoon.

March 28-April 30. Edges. The ice darkens.

April 3. Fissures. Ice piles up at the shore. Water holes.

April 5. A number of fissures, and their sizes increase.

April 9. Ice presses the shore.

April 10. In the morning, edges with a width of about 500 m. Then before noon the ice is carried away.

April 11. In the afternoon ice presses the shore.

April 12. Ice presses the shore. Hummocking of the ice is noticed.

April 13. A shift. In the afternoon the ice is carried away from the shore.

April 14 and 15. Ice far from the shore.

April 16. The ice has disappeared. Clear.

Appendix III. Information on the snow cover.

<table>
<tr><th rowspan="2">Date</th><th colspan="2">Tsimliansk Agro-meteorological Sta.</th><th colspan="2">Lower-Chirskaia</th><th colspan="2">Kotelnikov</th></tr>
<tr><th>Presence</th><th>Height (cm)</th><th>Presence</th><th>Height (cm)</th><th>Presence</th><th>Height (cm)</th></tr>
<tr><td colspan="7">1952</td></tr>
<tr><td>Nov 26[1]</td><td>No snow</td><td>-</td><td>|*|</td><td>1</td><td>|*|</td><td>0</td></tr>
<tr><td>Dec 1</td><td>"</td><td>-</td><td>"</td><td>1</td><td>No snow</td><td>-</td></tr>
<tr><td>2</td><td>"</td><td>-</td><td>"</td><td>1</td><td>"</td><td>-</td></tr>
<tr><td>3</td><td>"</td><td>-</td><td>"</td><td>1</td><td>"</td><td>-</td></tr>
<tr><td>4</td><td>"</td><td>-</td><td>"</td><td>1</td><td>"</td><td>-</td></tr>
<tr><td>5</td><td>"</td><td>-</td><td>"</td><td>0</td><td>"</td><td>-</td></tr>
<tr><td>6</td><td>"</td><td>-</td><td>"</td><td>0</td><td>"</td><td>-</td></tr>
<tr><td>7</td><td>"</td><td>-</td><td>"</td><td>0</td><td>"</td><td>-</td></tr>
<tr><td>8</td><td>|*|</td><td>0</td><td>"</td><td>1</td><td>|*|</td><td>3</td></tr>
<tr><td>9</td><td>"</td><td>-</td><td>"</td><td>0</td><td>"</td><td>3</td></tr>
<tr><td>10</td><td>"</td><td>3</td><td>"</td><td>3</td><td>"</td><td>5</td></tr>
<tr><td>11</td><td>"</td><td>3</td><td>"</td><td>3</td><td>"</td><td>5</td></tr>
<tr><td>12</td><td>"</td><td>2</td><td>"</td><td>3</td><td>"</td><td>5</td></tr>
<tr><td>13</td><td>"</td><td>0</td><td>"</td><td>2</td><td>"</td><td>5</td></tr>
<tr><td>14</td><td>"</td><td>0</td><td>"</td><td>0</td><td>"</td><td>4</td></tr>
<tr><td>15</td><td>"</td><td>0</td><td>"</td><td>0</td><td>"</td><td>2</td></tr>
<tr><td colspan="7">1953</td></tr>
<tr><td>May 26</td><td>|*|</td><td>9</td><td>|*|</td><td>29</td><td>|*|</td><td>12</td></tr>
<tr><td>27</td><td>"</td><td>8</td><td>"</td><td>27</td><td>"</td><td>11</td></tr>
<tr><td>28</td><td>"</td><td>7</td><td>"</td><td>26</td><td>"</td><td>11</td></tr>
<tr><td>29</td><td>"</td><td>4</td><td>"</td><td>19</td><td>"</td><td>7</td></tr>
<tr><td>30</td><td>"</td><td>2</td><td>"</td><td>16</td><td>"</td><td>2</td></tr>
<tr><td>31</td><td>"</td><td>0</td><td>"</td><td>11</td><td>No snow</td><td>-</td></tr>
<tr><td>Apr 1</td><td>No snow</td><td>-</td><td>|*|</td><td>9</td><td>No snow</td><td>-</td></tr>
<tr><td>2</td><td>"</td><td>-</td><td>"</td><td>4</td><td>"</td><td>-</td></tr>
<tr><td>3</td><td>"</td><td>-</td><td>|*| 3/4</td><td>2</td><td>"</td><td>-</td></tr>
<tr><td>4</td><td>"</td><td>-</td><td>" 3/4</td><td>-</td><td>"</td><td>-</td></tr>
<tr><td>5</td><td>"</td><td>-</td><td>" 3/4</td><td>-</td><td>"</td><td>-</td></tr>
<tr><td>6</td><td>"</td><td>-</td><td>" 3/[illegible]</td><td>-</td><td>"</td><td>-</td></tr>
<tr><td>7</td><td>"</td><td>-</td><td>" 1/2</td><td>-</td><td>"</td><td>-</td></tr>
<tr><td>8</td><td>"</td><td>-</td><td>" 1/[illegible]</td><td>-</td><td>"</td><td>-</td></tr>
<tr><td>9</td><td>"</td><td>-</td><td>" 1/10</td><td>-</td><td>"</td><td>-</td></tr>
<tr><td>10</td><td>"</td><td>-</td><td>No snow</td><td>-</td><td>"</td><td>-</td></tr>
<tr><td>11-30</td><td>"</td><td></td><td>"</td><td></td><td>"</td><td>-</td></tr>
<tr><td colspan="7">1954</td></tr>
<tr><td>Apr 12[1]</td><td>No snow</td><td>-</td><td>|*|</td><td>2</td><td>|*|</td><td>2</td></tr>
</table>

1 - There was no snow in the remaining days.

Appendix IV

Changes in Temperature and Humidity of the Air with Distance

km	(-) Spring		(+) Autumn		km	(-) Spring		(+) Autumn		km	(-) Spring		(+) Autumn	
	K_t	K_e	K_t	K_e		K_t	K_e	K_t	K_e		K_t	K_e	K_t	K_e
0,9	20	4	5	1	19	48	60	33	16	50	66		57	
1,0	20	5	5	1	20	49	62	34	18	51	66		58	
1,1	21	5	5	1	21	49	64	35	18	52	67		58	
1,2	22	6	6	1	22	50	66	36	19	53	67		58	
1,3	26	6	6	1	23	50	67	37	20	54	68		59	
1,5	28	6	7	1	24	50	69	38	21	55	68		59	
1,6	29	6	7	1	25	51	71	38	22	56	69		59	
1,9	30	8	8	1	26	52	72	39	23	57	70		59	
2,0	39	8	8	1	27	53	74	40	24	58	70		59	
2,4	32	10	10	2	28	53	74	41	25	59	70		60	
2,5	32	10	10	2	29	54	76	42	26	60	70		60	
2,8	31	11	11	2	30	54	77	43	27	61	71		61	
3,0	34	12	11	2	31	55	78	43	28	62	71		61	
3,2	34	13	12	2	32	55	79	44	29	63	72		61	
3,5	35	13	13	2	33	56	80	45	29	64	72		62	
4,0	37	16	13	3	34	57	81	46	30	65	73		62	
4,5	38	19	14	3	35	58	82	47	30	66	73		62	
5	35	21	15	4	36	58	83	48	30	67	73		63	
6	40	25	17	5	37	58	84	49	>31	68	74		63	
7	41	29	18	6	38	59	>84	50	>31	69	74		63	
8	42	33	20	6	39	60	—	50	31	70	74		63	
9	43	36	22	7	40	61	—	51	—	71	74		63	
10	43	40	23	8	41	61	—	52	—	72	74		63	
11	44	42	25	9	42	62	—	53	—	73	74		63	
12	41	45	26	9	43	62	—	53	—	74	75		63	
13	45	49	27	10	44	63	—	54	—	75	75		64	
14	45	51	28	11	45	63	—	54	—	76	75		64	
15	46	54	29	12	46	64	—	55	—	77	75		64	
16	46	56	30	13	47	65	—	55	—	78	76		64	
17	47	57	31	14	43	65	—	56	—	79	76		64	
18	18	59	32	15	49	66	—	57	—	80	76		64	